PETROLEUM PROCESSING

VOLUME 2, NUMBER 8 AUGUST, 1947

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FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

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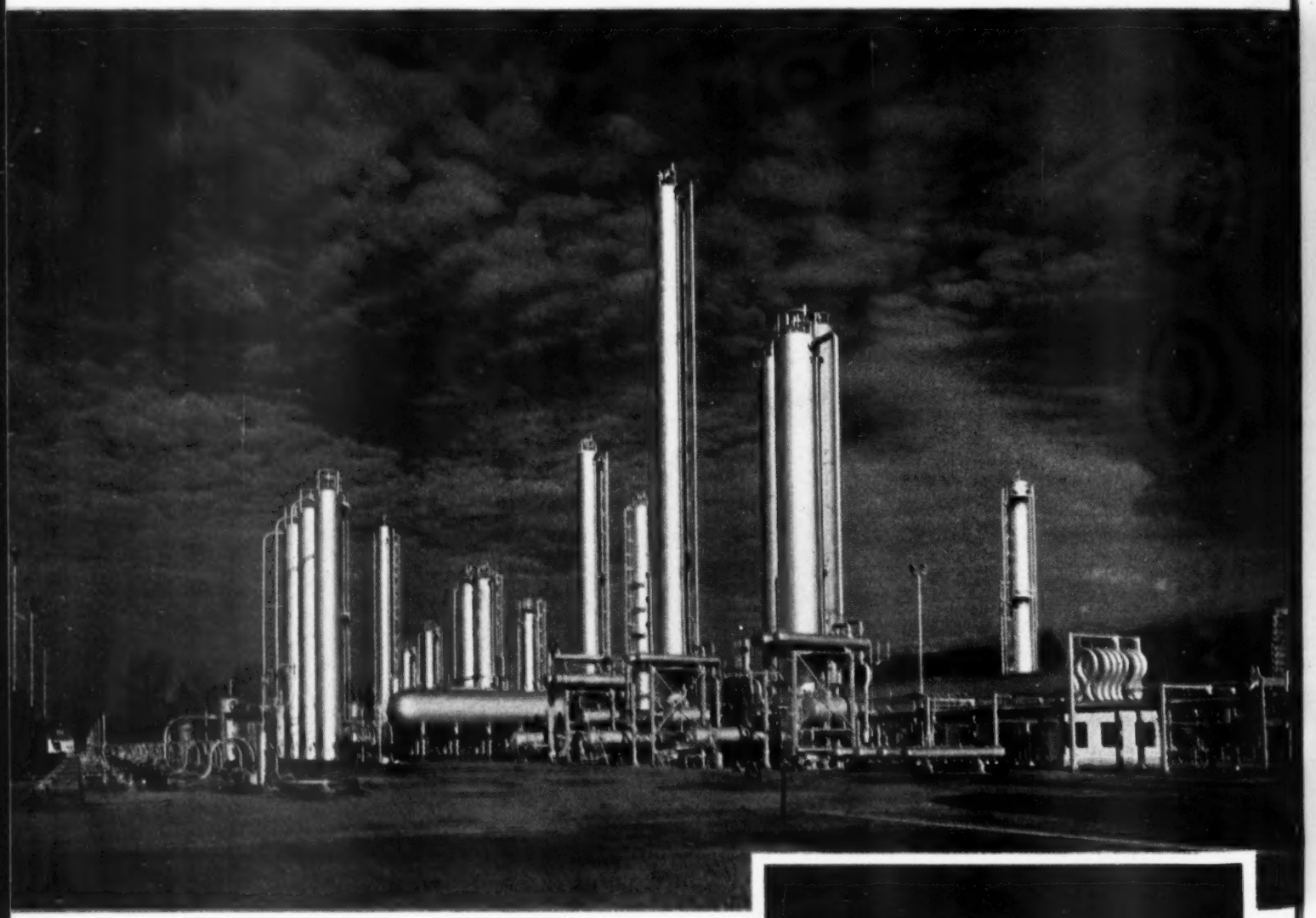

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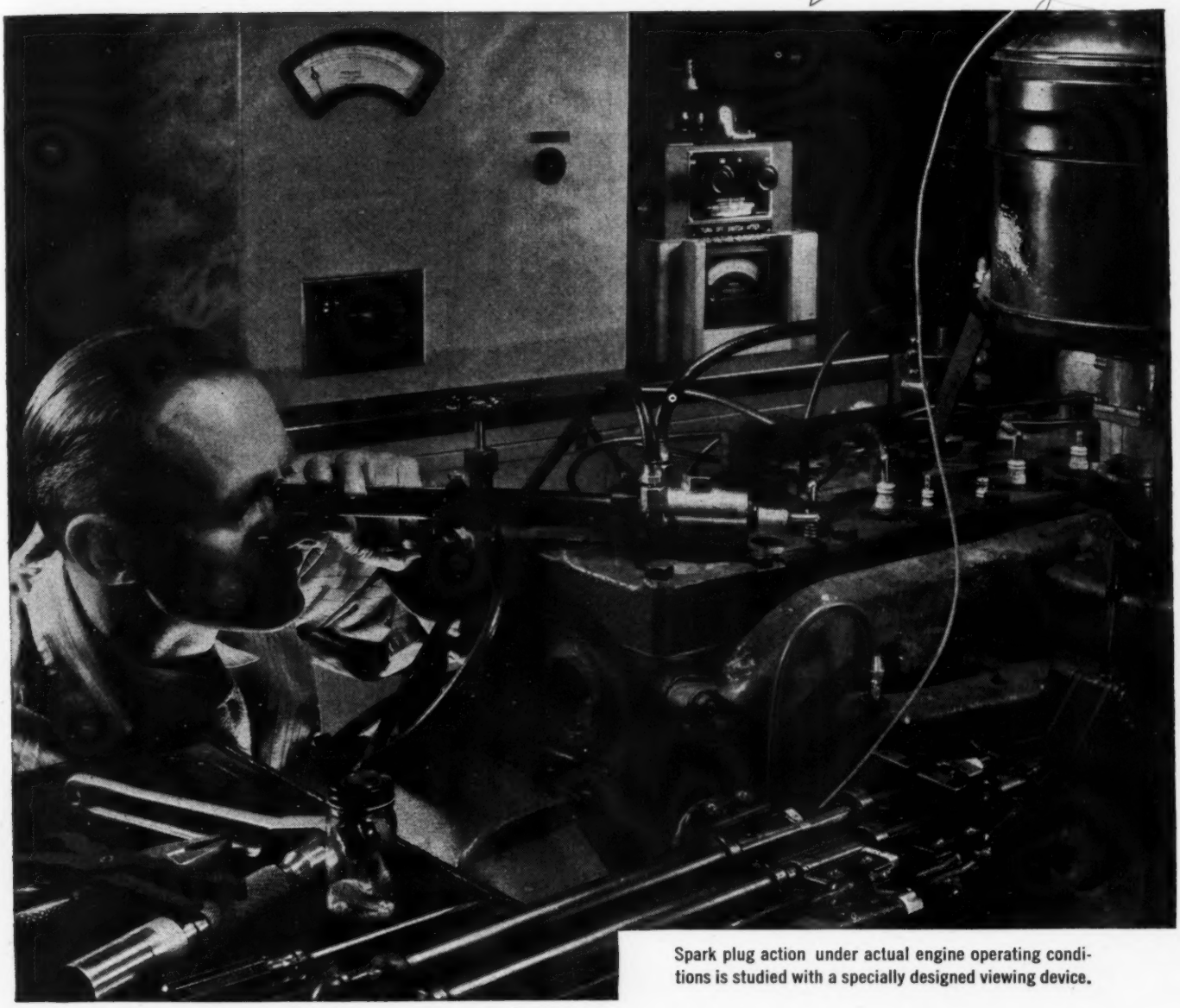

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PETROLEUM PROCESSING

Of Crude Petroleum and Natural Gas
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REFINERY OPERATION, MAINTENANCE, EQUIPMENT, DESIGN

FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

FEATURED IN THIS ISSUE

● *BUILDING OF NEW LUBE OIL AND WAX manufacturing plants, held up during the war, is under way to make up for lost time. Facilities being installed in 15 U.S. refineries include new developments in solvent refining, feed preparation, clay finishing and additive blending. PETROLEUM PROCESSING editors a year ago started to arrange for articles on special features of the new lube oil manufacturing technology installed in the new units. The first article in this group, "Modern Manufacture of Lubricating Oils", appears on pg. 594.*

●

● *TURNAROUND IN PICTURES: Operation of modern catalytic cracking plants and other high-investment refinery units requires developing a technique for speedy maintenance and repair work on these units when they come off stream for routine inspections. One large refinery photographed every step in its first Turnaround on a Fluid unit to aid in further study to improve its Turnaround technique. PETROLEUM PROCESSING arranged for the exclusive publication of selected photographs of important operations. See pg. 569.*

●

● *COVER PHOTOGRAPH: The picture on the cover is one of the photos from Turnaround Technique. In a preparatory operation steam boiler pressure relief valves are being tested. A pair of workmen slowly close the steam discharge line while another operator watches the pressure dial. Valves that don't vent correctly are tagged for removal when the unit comes down.*

Photos Courtesy of M. W. Kellogg Co.

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PETROLEUM PROCESSING
AUGUST, 1947

Effect of Taft-Hartley Act on

REFINERY LABOR RELATIONSHIPS

As Discussed by
C. H. METZ, Jr.
Industrial Relations Director
Standard Oil Co. (Ohio)

IN future labor negotiations under the new Taft-Hartley act, refinery management will have to decide:

1—Whether it will recognize a union as the representative of its employees without certification by the National Labor Relations Board, and, in the absence of such certification, if it is willing to include supervisory employees, guards, or professional workers in the unit recognized.

2—Whether it will grant union security (union shop, dues check off, etc.), or insist that membership in a labor organization be a question for each individual employee to decide for himself.

3—Whether it wants to enter into any agreement which purports to deprive it of its rights to recourse under the provisions of the law.

These points were raised by C. H. Metz Jr., Cleveland, industrial relations director of Standard Oil Co. (Ohio) in an address before a regional industrial relations meeting of the Western Petroleum Refiners Assn. at Lansing, Mich., July 17. The meeting was sponsored by W.P.R.A. to discuss the new law, more correctly known as the Labor-Management Relations Act of 1947.

Although Mr. Metz made it clear in his talk that the answers to the above questions are in all cases a matter of policy decision for individual concerns, he stated that in his personal opinion refinery management should:

1—Require a union, demanding recognition, to secure certification by the NLRB and

2—Continue to seek a no-strike pledge in its contracts.

In his opinion, stable employer-employee relations can be established under the act, but only if both management and labor will recognize their individual responsibilities and live up to the letter of the law.

"We now have a new law defining the responsibility of employers, employees, and labor organizations and their relationships to each other," said Mr. Metz. "It is designed to make these parties recognize that the public interest is paramount. . . . It behooves management, therefore, to comply with the law in the interest of establishing stable employer-employee relations."

He cautioned management against taking undue advantage of its rights as recognized under the law or using it for union busting or gaining revenge for past grievances.

"Industry," he continued, "should exert its sincerest efforts to make the Taft-Hartley act work. If it fails to reduce labor turmoil, we may expect more government regulations, compulsory arbitration, and labor relations courts—restrictions that neither labor nor management want."

In other portions of his address, Mr. Metz discussed the new law with respect to featherbedding, restrictions on payments to union representatives, and notification of termination or modification of contract.

The act, he pointed out, makes featherbedding an unfair labor practice on the part of unions. "Therefore," he continued, "for an employer to voluntarily agree to make certain payments would not constitute an unfair labor practice either on the part of the employer or the union . . . Voluntary agreements with respect to call-in pay, lunch periods, rest periods, down time, holiday pay, etc., may be negotiated and would be legal and binding on the parties."

On the question of payments to union representatives, Mr. Metz outlined the provisions of the act pertaining to such payments as well as to employer contributions to welfare funds. He stressed the point that this portion of the law "does not prohibit payments made to union representatives who are employees for time spent during working hours in conferring with management . . . An employee who is a union representative may be compensated on a 'no loss, no gain' basis for all time spent in conferring with management on matters pertaining to the employer-employee relations—this would include, of course, time spent during working hours in handling grievances at any stage of the grievance procedure."

With respect to that section of the act requiring 60 days written notice in the event a party to a collective bargaining agreement desires to terminate or modify it, Mr. Metz raised the question as to whether the procedure applies only at the expiration of a contract, or whether it also applies to the re-opening of certain sections prior to the designated expiration date. "Keeping in mind the purpose of those provisions to avoid strikes and lock-outs by requiring adequate prior notice and negotiations," he reasoned, "it follows as a logical conclusion that the provision for 60 days' written notice is applicable to all re-openers."

Those sections of Mr. Metz's talk dealing with the three points raised as the beginning of this article are given below:

NLRB Certification

It is not required that the National Labor Relations Board first conduct an election among your employees as a condition to your recognizing a labor union as their representative. If you are satisfied that a labor organization *does* represent your employees, you may voluntarily recognize the union and enter upon contract negotiations with it. If you *refuse* to recognize a union without prior certification by the Board, it would be necessary for the *union* to seek certification and for the Board to hold an election on the question. The Board

would then have to determine the appropriate unit.

Unless the parties agree, the Board is precluded by the provisions of the Taft-Hartley Act from including supervisory employees in any unit and from including guards in units which also cover other employees, or from certifying a labor organization as the representative of guards where such organization also represents other classes of employees. In determining the appropriate bargaining unit, the Board is also precluded from including professional employees with other groups of employees unless a majority of the employees in the professional group indicate their willingness to be so included.

If you recognize a labor organization as the representative of your employees *without* the Board's certification, any or all of the above-mentioned classifications of employees *may be* included in the recognized unit.

Here a policy question arises as to whether or not, in the absence of Board certification, you are willing to recognize a union as the representative of your employees and whether or not you are willing to include any of such groups of employees in the unit recognized. It would appear that it is the more sound approach to the solution of this problem to require a union demanding recognition to secure certification by the Board.

Union Security

Prior to World War II, the oil industry operated traditionally on an open shop basis. With the approach of World War II, employees in the refining branch of the industry were largely organized by labor unions. Then, during the war years, the demand was made by these organized groups for various forms of union security. This was denied in many instances by the employers in the oil industry who had operated for so many years on the open shop basis. The resultant dispute was resolved by the War Labor Board which, in most cases, ordered the newly devised maintenance of membership clause to be inserted in contracts.

After Aug. 23, 1947, the new law will require that, before you enter into a union security agreement, an election be conducted by the NLRB among all the eligible employees in the bargaining unit to determine whether or not the union shall be authorized to negotiate on the matter of union security.

Remember that the closed shop is outlawed by the Taft-Hartley Act and that any other form of union security, such as the union shop, maintenance of membership, etc., is subject to the restrictive features in the act relative to the NLRB conducting elections.

The law does not require you to agree to *any* form of union security even though your employees may have authorized their representative to negotiate on this question. We, as employers, will have to decide individually whether we are willing to grant union security in the form of union shop or lesser forms of union security or whether we want to insist that the question of membership in a labor organization is a matter for each individual employee to determine for himself. The determination of this question is, of course, a policy matter for each individual company.

Waiver of Rights

The recently negotiated contract between the John L. Lewis United Mine Workers and the coal operators has attained a great deal of notoriety because of obvious attempts to preclude the various provisions of the contract from the operations of the Taft-Hartley Act. For example, provision is made that in the case of any dispute whatever between the parties, the dispute shall be settled in accordance with the provisions of the contract. The provision is sufficiently broad to cover a waiver of the rights of the parties to file charges before the NLRB as well as to file suit in the courts.

The question arises immediately as to the legal effect of such a contract provision as that contained in the Lewis agreement. There are some authorities who hold that the NLRB and the court may not, by the operations of the provisions of any agreement, be denied jurisdiction over cases where they specifically have such jurisdiction under provisions of the law.

A question of public policy is involved. The fundamental purposes and objectives of the act must be kept in mind. Congress has found that certain acts and practices interfere with the free flow of interstate commerce. They have declared certain of these to be unfair labor practices subject to restraint by the NLRB and certain of them to be illegal and subject to the jurisdiction of the Federal Courts in suits for damages. It is doubtful that labor and management can obviate the fundamental purposes and objectives of the law by entering into a private agreement not to resort to the processes of the law.

At any rate, regardless of the validity of such agreements, there seems to be little wisdom in pursuing such a course as that followed by the parties to the coal agreement. Here, again, you will, of course, have to determine whether or not you want to enter into any agreement which purports to deprive you of your right to recourse under the provisions of the law.

Considerable publicity has been given to the attitude of the unions towards all no-strike clauses in view of the liabilities imposed by the new law. The point has been made by many leaders of organized labor that they will no longer consent to the inclusion of no-strike clauses in labor agreements. Of course, these clauses are desirable principally because of the psychological effect they have on the employees, particularly those who might be inclined to engage in wildcat strikes. It is reasonable to believe, however, that even in the absence of a specific no-strike clause, in the case of contracts having a definite contract period and which provide a procedure for the final determination of all disputes involving the interpretation or application of the contract, the courts would hold that for the union to engage in a strike or the employer to engage in a lock-out would constitute a violation of such agreement. Such agreements seem to imply that both parties will comply with the terms established therein and, therefore, that the union shall not strike and that the company shall not lock out. It would appear desirable for managements to continue seeking a no-strike pledge in their contracts.

About the Author

C. H. Metz, Jr., author of the above ideas on the application of the Taft-Hartley Act to refinery labor negotiations, knows both sides of the employer-employee picture.

He began his oil industry career as a water drawoff boy for Standard Oil Co. of N. J. at its Charleston, S. C., refinery in 1922. Two years later he was transferred to Tampico, Mexico, as a stillman for Transcontinental Petroleum Co., a Jersey Standard subsidiary. After three years in Mexico he returned to Charleston for a few months and then joined Standard Oil Co. (Ohio), in 1927.

He started with Sohio as a cracking coil stillman at the No. 1 Refinery in Cleveland. He was named foreman a year later, assistant superintendent of the refinery in 1929, superintendent in 1937 and manager in 1944. Two years ago he was appointed to the position of industrial relations director for all of Sohio's operations.

Fig. 1—Daily meeting of master mechanic of Gulf's Philadelphia refinery (left foreground) with his foremen to plan the following day's work in the Turnaround of the Fluid catalytic cracking unit

TURNAROUND TECHNIQUE

Special Handling Equipment Built Into the Unit, Methodical Preparations and Coordinated Inspection and Repair Programs Reduce the Down Time for a Modern Catalytic Cracking Plant

WHEN a modern catalytic cracking unit is taken off stream for routine inspection and repair and replacement of equipment parts, interest of all operating heads in the plant is directed to have the Turnaround completed in the least possible time. The large investment in the unit and, especially today, the pressing demand for the many thousand barrels of high quality motor fuel it can turn out every operating day, makes the time the unit is down costly to the refinery, even when figured in hours.

Good engineering has been applied to shorten the time the unit has to be shut down, as well as to keep it running without interruption for long periods when it is on stream. Special handling equipment has been built in to expedite removing and replacing heavy parts of equipment, and platforms and walkways to make it easier and safer for workmen to perform their tasks. Special techniques have been developed for making repairs and replacements in the shortest time possible. Preparations for the Turnaround start weeks before the unit actually comes down.

Many design features and techniques for the Turnaround, as provided for a 23,000 b/d charge stock Fluid catalytic cracking unit at the Philadelphia refinery of Gulf Oil Corp., are shown in a series of photographs taken when the unit came down for its first routine inspection and repairs after 9 months operation. This is believed to be the first time that complete photographs have been secured of all the steps in the Turnaround of a modern cracking unit. The photos, running into several hundreds, were taken by engineers of Gulf Oil Corp., and of M. W. Kellogg Co., which designed and installed the Fluid unit at the Philadelphia refinery. The selected photographs shown here depict some of the construction features and techniques which helped shorten the unit's first Turnaround.

Approximately 360 men were employed on the unit during this Turnaround, including practically every industrial craft from welder to painter, pipefitter to carpenter, machinist to insulator, boilermaker to laborer. In spite of the difficult working conditions for many of the craftsmen due to altitude and confined spaces, not a single lost time accident occurred, which is considered a remarkable record for this sort of industrial operation.

Every day, the master mechanic of the Gulf refinery met with his crafts foremen to outline and plan the following day's work. Plans made at these meetings governed the work of the 360 men concentrated on the Turnaround, since it was essential that each foreman plan his work in relation to that of other crafts if loss of manhours was to be avoided. Fig. 1 shows one of the daily meetings of the master mechanic with his foremen. The cracking section of the Fluid unit at the Gulf refinery is shown in Fig. 2.

This being the first Fliud unit to be operated by Gulf Oil Corp., though three more are being built, every major vessel was entered and thoroughly inspected during the Turnaround. This in itself is no small task as is shown by the fact the regenerator is 42 ft. in diameter and 35 ft. high, the reactor 27 by 50 ft. Most of the heat exchanger bundles were pulled to check the extent of fouling during the nine months' run, and to indi-

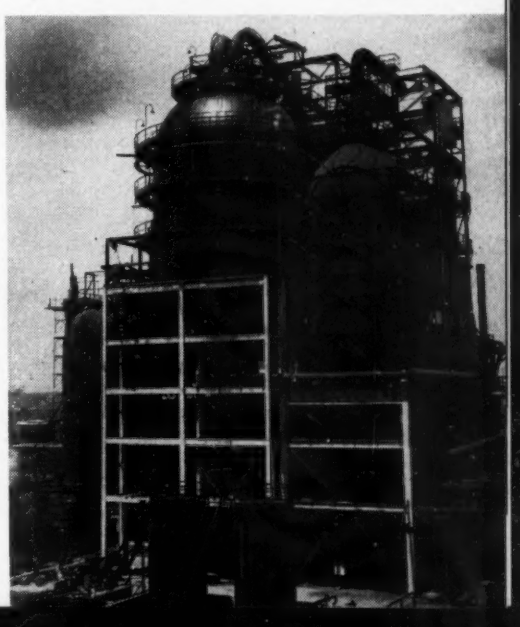


Fig. 2—Cracking section of the Fluid unit at Gulf Oil Corp.'s Philadelphia refinery

Fig. 3—Preparatory to the actual Turnaround, operators lubricated threads on flange bolts of condensers for easier removal of the heads

Fig. 4—Also preparatory, operator wires a blank to a heat exchanger line for more prompt installation when unit actually comes down

cate what might be expected during the next year's operations.

Despite the comprehensiveness of the survey, the Fluid unit was found to be in such good condition that the total number of manhours expended for preparation, inspection, cleaning and repair was less than anticipated.

Long before the Fluid unit was taken off stream, many preliminary moves were made to save time when it was actually down. For example, electrical welding machines were moved to high floors where they would be convenient for use and positioned so they could be quickly connected.

Other examples of time-saving preliminary planning were: Moving power winches to the heat exchanger section, to be used in pulling tube bundles; setting up special valve testing and warehouse departments to handle the increased call on these facilities; building scaffolding at awkward and dangerous work places; tagging valves for removing or repacking; prefabricating known replacement parts; marking drill hole sites in piping, to list only some of the preparatory work.

Many weeks before the unit was scheduled for the Turnaround, the arrangements to shorten the off-stream time were quietly and steadily progressing. For example, a few days before the unit came down, operators lubricated the threads on the flange bolts of the condensers, as shown in Fig. 3. This made easier removing the heads so that tube bundles could be pulled out and inspected.

In another preparatory operation, the master mechanic had made up a blanking list with the location and diameter of all pipe flanges which were to be blanked off. These locations had been tagged and checked, blanks prepared and actually wired in place ready to be inserted and then checked again. Then all that remained to do when the Turnaround began was to remove a couple of bolts from the flange, loosen the others, slide the blank and gasket in and tighten up.

In Fig. 4 an operator is wiring a blank to the transfer line leading to a heat exchanger, a heavy gas oil cooler, while the unit is in normal operation. The blank will isolate the pipe line from the exchanger, enabling the tube bundle to be pulled out safely and inspected without danger of backflow. It will also permit pressure testing of the shell for leaks.

Fig. 5—Marking spot in line to be drilled during Turnaround so depth of metal can be measured and safety of line determined

Engineers marked the spots where test holes were to be drilled in pipe lines when the unit was shut down so that the depth of the metal could be measured and thus safety of the lines determined. Such test holes are carefully selected and usually located at bends in lines, where erosion will be greater than in straight lengths. See Fig. 5. After drilling and measuring wall thickness, drill holes are tapped, a plug screwed in and the plug sealed with weld metal. An additional test hole will be drilled on the next Turnaround to check metal loss.

Results of such testing during this Turnaround indicated the unit could have been operated for a considerably longer

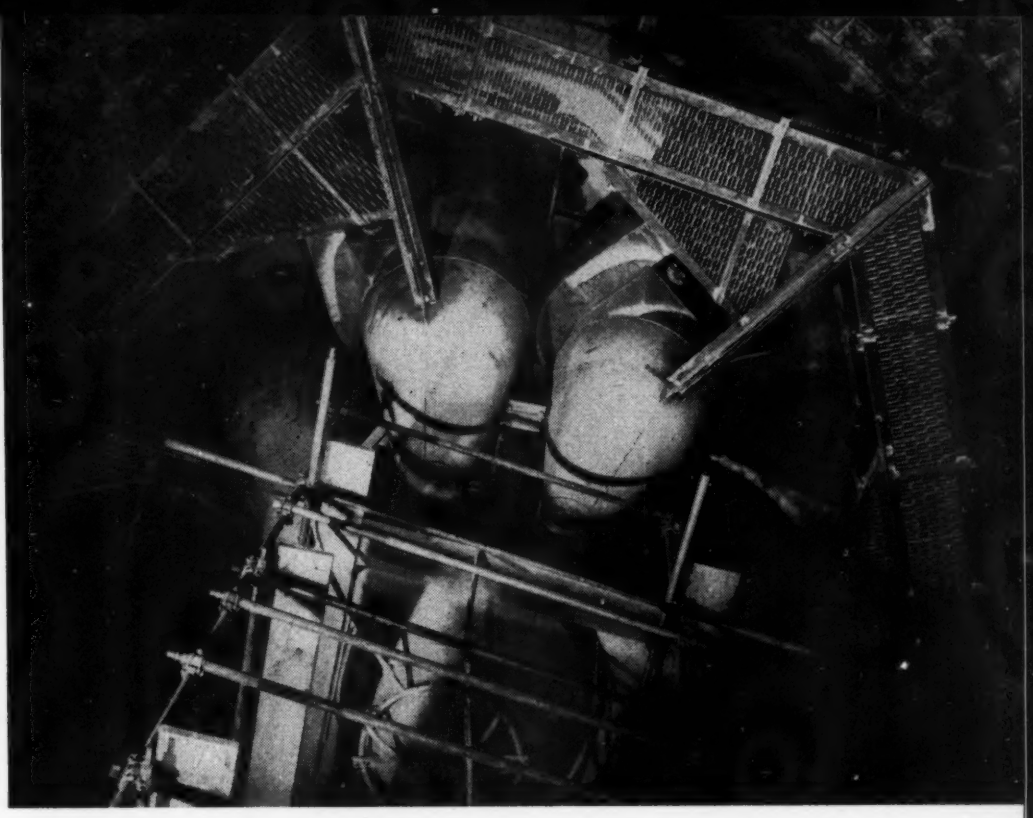


Fig. 6—New type of block insulation for regenerator interior was inspected during the Turnaround and found to be in good condition. Upper right hand corner shows stainless steel shingles installed to protect and retain the block insulation of the top cone

Fig. 7—Permanent steel walkway in top of regenerator provided saving in labor during the one Turnaround which more than paid the cost of installing the walkway. Wood and tubing scaffold directly below cyclone separator is a temporary structure

period. This was in part due to improved design of the catalyst piping which materially reduced erosion. Lines are shorter and more direct due to rearrangements of equipment and built-in expansion and rotation joints.

Just before a Turnaround is an opportune time to test safety valves on the steam boiler. In the cover photo of this issue of PETROLEUM PROCESSING, a pair of workmen have slowly closed the steam discharge line from a steam boiler in normal service, while an engineer below watches the pressure dial. When the pressure reaches that set for the safety valve, if functioning properly, it opens and vents steam to the atmosphere. If the valve does not open correctly it will be removed and repaired during the Turnaround. All safety valves which can't be tested while the unit is in operation are removed and sent to the valve testing department of the machine shop for testing, cleaning and repairing.

New design features of the regenerator were examined with particular interest during this first Turnaround of the Fluid unit at the Gulf Oil Corp. Philadelphia refinery.

A new type of gunite insulating lining developed by Gulf in conjunction with engineers of M. W. Kellogg Co. and used on the interior of the regenerator was submitted to most careful inspection and found to be in excellent shape. This lining was prepared by, first resistance welding some 17,000 carbon steel welding studs in rows perpendicular to the shell. Then a 2.5-in. layer of insulating concrete (Kelcrete) was applied by gun up to the shoulder of the welding stud.

Next, 0,75-in. thick Hexsteel panels, (similar to subway grating) approximately 2 x 3 ft. in dimensions, were welded to the studs and a 0.75-in. layer of refractory concrete was gunited in to fill the armor mesh and anchor it securely to the 2.5-in. Kelcrete foundation. This material is a hard, abrasion-resistant concrete formed of crushed firebrick and cement. Should a failure develop in this lining it would be repaired by guniting a little more material into the damaged area.

Several advantages are cited for this type of lining over previous types used in regenerators of Fluid "cat crackers:"

1—More stable and rugged, showing less crumbling due to temperature fluctuations and sudden surges of catalyst.

2—Lower initial cost, 50% lower than other insulations previously used, and lower inventory value for warehouse stocks for maintenance.

3—Can be repaired quickly and at low cost without use of expensive equipment or materials.

Fig. 6 shows the new type of gunite lining used on the interior of the regenerator, also the stainless steel shingles used to protect and retain the block insulation of the top cone of the regenerator. The alloy shingles are resistance-welded to Nelson studs welded to the metal shell of the regenerator.

Another new design feature in Gulf's Fluid unit is a permanent steel walkway installed in the top of the regenerator to facilitate inspection of the cyclone separators. See Fig. 7. Entrance to the walkway is from the top manhole of the regenerator. Saving in labor during this one Turnaround on this unit more than paid the cost of installation of the walkway. Due to precautionary steps taken by the design engineers, the cyclone separators in both regenerator and reactor were found to be in good condition from the 9-months' run of the unit and no repairs to this equipment were necessary.

In one "unbuttoning" job after the unit is down, boilermakers use an air-operated impact wrench for removing nuts and bolts from exchanger heads. One man prevents the head of the bolt from turning while the other gurs the air motor to remove the nut. Flange

Fig. 8— Boilermakers removing nuts and bolts from exchanger head with air-operated impact wrench

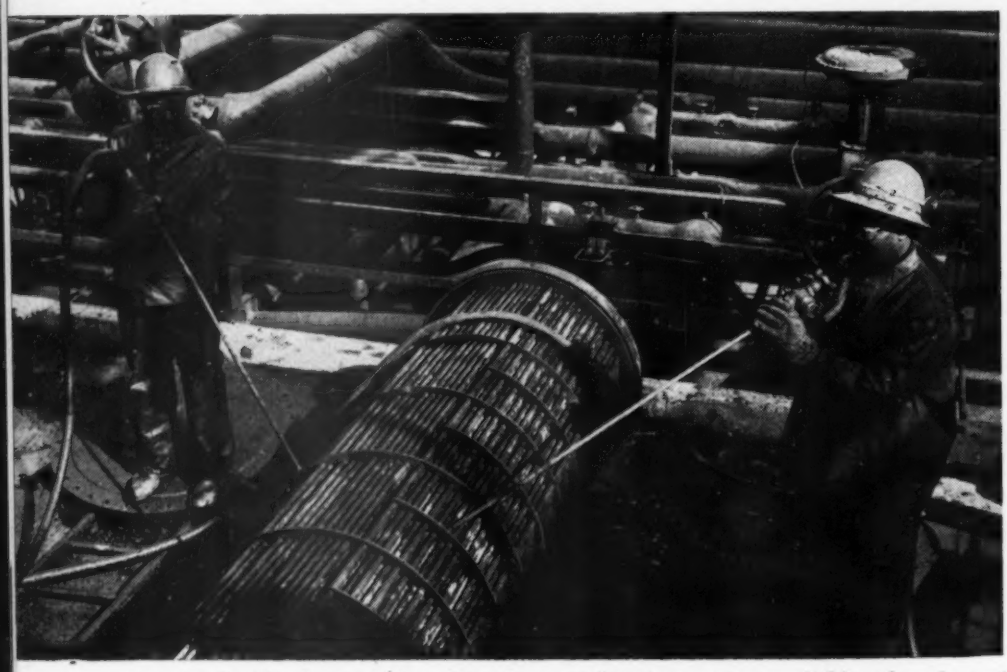


Fig. 9—Air-blowing exterior of condenser tubes to remove small bits of scale and other debris. Algae and rust are previously removed by washing

Fig. 10—Another step in Turnaround technique in cleaning heat exchangers. When blocked tube is encountered, obstruction is bored through by rotation of a sharp, pointed tip on long rod attached to air motor

bolts were oiled before the Turnaround to increase the speed of removal. Fig. 8 shows the use of the impact wrench.

First step in cleaning a condenser tube bundle, after its removal from the shell, is to wash off the accumulated rust-algae concretions deposited on the water side of tubes. Cost of installing a chlorine treating system for cooling water to the Fluid unit to prevent algae was weighed against operating efficiency and annual cleaning using untreated but filtered water and the economic balance was found to favor the latter.

After the algae and rust have been removed, high pressure air is used to blow small bits of scale and other debris away from the tube bundle exterior as shown in Fig. 9. Shells of the condensers are washed, blown and, if necessary, scraped in the cleaning operation.

Scale is blown out of the tubes of heat exchangers by scooting air through them. An easily manipulated valve on the air line and a long feeder tube permit full air blast to be directed anywhere along the exchanger tube. When a blocked tube is encountered, the obstruction is actually bored through by the rotation of a sharp, pointed tip on a long rod attached to an air motor, as shown in Fig. 10. After the obstruction is removed, the tube is flushed with water under pressure and blown with air. Only a few tubes required this treatment.

The value of incorporating, in original design, wear plates at points in catalyst-carrying lines most subject to eroosion was demonstrated by inspections during the Turnaround. For example, impingement of catalyst particles had caused erosion on the sides of the line at the junction of carrier line, spent catalyst standpipe and air line. Benefitting by previous experience, design engineers had provided for this contingency by installing wear plates inside the line at such points.

Erosion was also found in the wear plates of the reactor risers at the oil injection points under the two regenerated catalyst standpipes. At these points catalyst slurry, regenerated catalyst, steam, fresh feed and recycle oil all enter the risers on their way to the reactor. The plates were replaced at little cost during the Turnaround. However, without the plates, the unit would have had to be shut down because of erosion through the pipe walls.

Evidences of erosion were also found on the top side of the large central nozzle on the inner face of one of the oil injection heads, where steam and catalyst slurry from the base of the fractionator sweep upward at high velocity as they leave the nozzle. The remaining 6 nozzles were in good condition. The damaged central nozzle was repaired at small time and cost. Had it gone unnoticed it might have caused an unscheduled shut down of several days.

Visual inspection of the interior of lines of the Fluid unit was an important part of the Turnaround and in many cases the lines were large enough to permit the inspectors to get inside them for the examination. They were lowered into the lines, and into vessels of small diameter, by means of a leather harness and block and tackle, somewhat similar to a boatswain's chair, as shown in Fig. 11. Usual accessories carried are flash-

Fig. 11—Turnaround inspector being lowered into stripping well of the reactor to check interior walls

light, respirator and small hammer. The inspectors check condition of interior linings and measure rate of wear and take data for their records so that they can reasonably predict service life in advance and so prepare replacements for the next Turnaround.

The catalyst-polished thermo well in the carrier line returning recycle catalyst to the regenerator showed erosion in the alloy metal just at the point where the tube juts from the wall, indicating that eddy-like currents had been set up by the thermo wells jutting into the air-catalyst stream, causing maximum wear on these thermo wells. This tube was replaced. The instrument department of the refinery pulled out and checked all thermo wells for wear during the Turnaround. Some in the regenerator are 17 ft. long. Most thermocouples were renewed as a precautionary measure, especially those in high temperature service. None were replaced during the 9 months' run.

Advantage was taken of the shutdown to clean the basin of the water cooling tower, where during 9 months' operation a considerable amount of mud, slush, pitch and other debris had accumulated. In operations of the Fluid unit, water flows from the basin to three Worthington steam, turbine-driven centrifugal pumps, each delivering 17,500 gpm, which return the cooled water to the unit. The water pumps had given excellent service and it was not necessary to pull the heads for inspection.

To facilitate and expedite the handling of extra-heavy equipment during the Turnaround, Gulf Oil Corp. engineers had designed special overhead trolleys which were built into the unit when it was erected. Such an arrangement was used for handling the spent catalyst slide valves, which are 34 in. in diameter and weigh approximately 2.5 tons.

The valve, minus the hydraulic assembly for opening and closing the gate, was swung out of the spent catalyst standpipe on the trolley and special cradle shown in Fig. 12. Use of this equipment greatly shortened the time required to pull out the valve and put it back in place. All that was necessary was to remove the nuts and bolts and push the valve out. In addition to requiring fewer men, this method also is safer than conventional practice. As previously stated, the trolley beams are permanent installations.

The design of this Fluid unit provided for two 2.5-ton, 34-in. diameter hydraulically-operated slide valves for the spent catalyst standpipe, two 22-in. valves for the recycle catalyst standpipe and two 24-in. valves in each of the two regenerated catalyst standpipes. Should the lower valve fail for any reason, the top slide valve is put into immediate operation to prevent an unscheduled shut down. An extra slide valve was also provided for a spare for each different valve service. During the Turnaround the bottom, or operating, valve was removed, the top valve moved to the bottom operating position and the spare

Fig. 12—Swinging out the spent catalyst slide valve (weighing approximately 2.5 tons) on built-in trolley and special cradle bolted to the bonnet

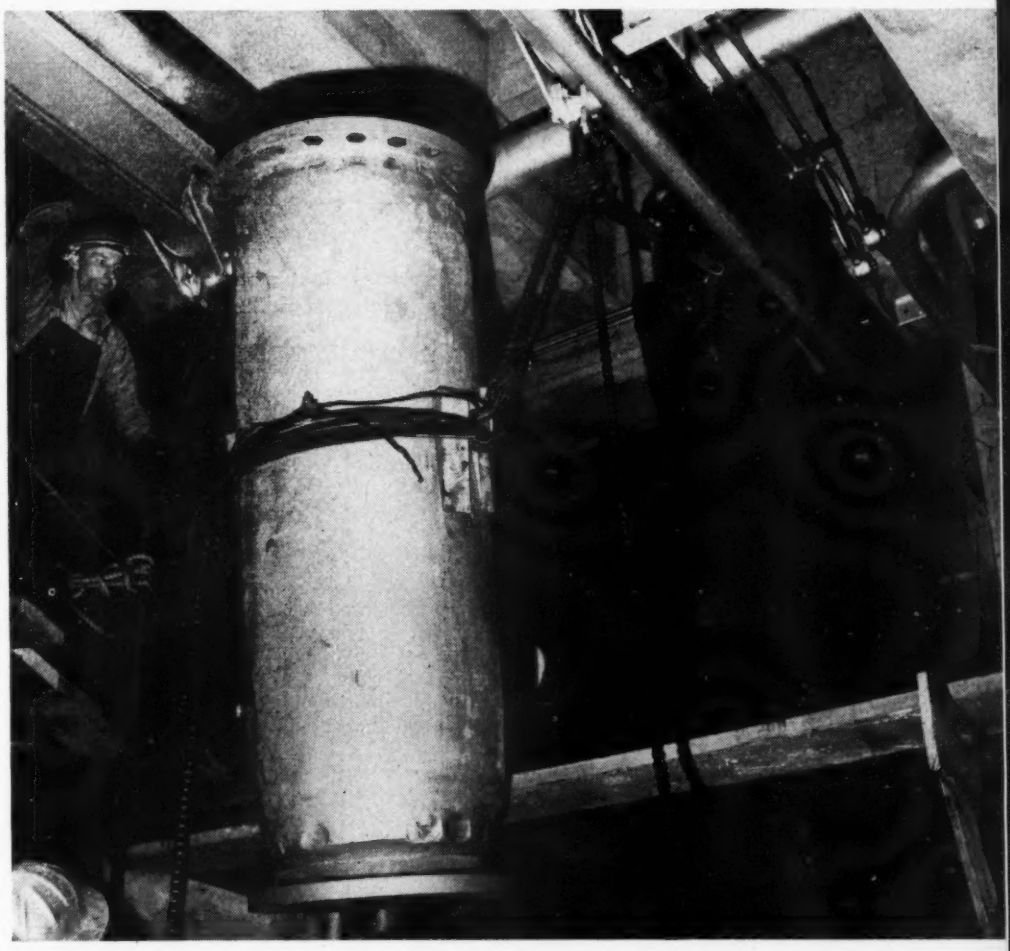


Fig. 13—Trolley beam arrangement is also used to remove the 30-in. diameter spool piece from discharge line of the air blower. The handling equipment was built in when the Fluid unit was constructed to expedite Turnaround operations

valve was placed in the top standby position. With this rotational system each slide valve will experience approximately the same rate of wear, and repairs can be made on the valve removed whenever convenient.

The excellent condition in which the operating slide valves on the Fluid unit were found, in the Turnaround inspection, is due to the reduced height of the unit. Short standpipes mean less static head above the slide valves and reduced the pressure above the valve from 10-15 to 5-10 psi. This in turn reduced the pressure drop across the valve with a reduction of velocity of catalyst through the valve, thereby lessening the erosion.

Another trolley beam arrangement built into the Fluid unit when it was constructed facilitated removal of the 30-in. diameter spool piece from the discharge line of the giant air blower which sweeps spent catalyst from the base of the reactor into the regenerator. The spool piece is lifted with handjacks as shown in Fig. 13 and then skid out of the way via a trolley and beam.

Two blowers are used on this "cat cracker." Each is a 2200 hp, three-stage, centrifugal blower driven by an Elliott steam turbine. Superheated steam enters at 165 psi and leaves at 28.5 in. of vacuum to drive the turbine. The blowers deliver 27,600 cu. ft. of air per minute at 17 psig. Inspection of impeller blades and other parts of the blower showed no signs of wear. Fig. 14 shows the head of the blower lifted a few feet to permit inspection. The equipment is being checked by engineers and mechanics at Gulf, Kellogg and the Elliott Co.

The trolley beam arrangement is also used to simplify the work of putting the spool piece and blower head back in place after inspection, thereby effecting a savings in man hours in the "buttoning up" of the unit preparatory to putting it back on stream.

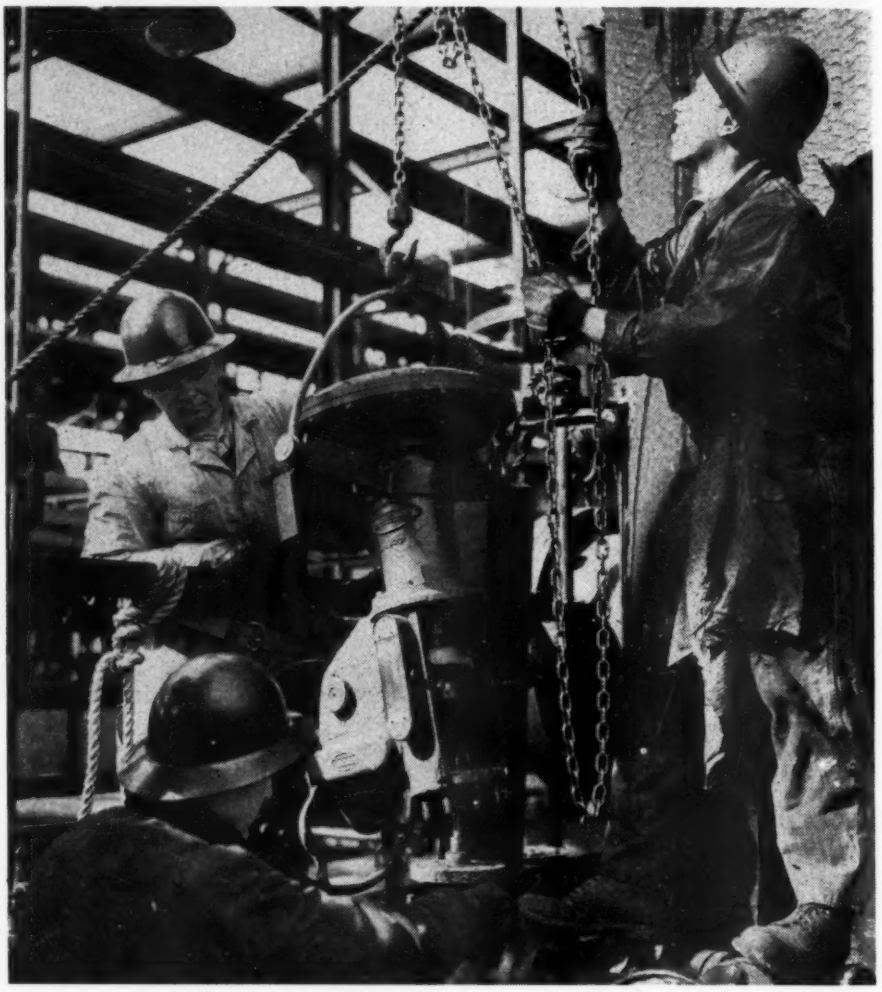


Fig. 15—Instrument department technicians removing an automatic valve by means of a special cradle during the Turnaround

Fig. 14—Lifting the head of the air blower a few feet permits inspection of impeller blades and other parts by engineers and mechanics

In the operation shown in Fig. 15, instrument department technicians are removing an automatic valve, using a special cradle for lifting the valve. The valve is never taken off the hook but is raised about 4 ft. to permit removal of the spool piece which contains the packing gland. After repacking, the spool piece was replaced and the valve again bolted into position. This procedure was followed for each of the approximately 50 hand-wheeled automatic valves on the unit. All such valves were found in good condition and were repacked purely as a precautionary measure.

With the inspections all made, measurements taken to indicate what replacements will be required at the next Turnaround and all repair work completed, the Fluid unit was "buttoned up" and made ready to go on stream again. Oil feed was turned into the unit, but not all at one gulp. Starting with a small flow, the fresh oil feed was gradually stepped up at the rate of about 500 bbls. per hour to design capacity.

TOMORROW

... IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Technical data presented on allyl alcohol.**
- **National office of bibliography proposed.**
- **"Chemical Facts and Figures" of considerable utility.**
- **Hydrogen cyanide being produced from carbon monoxide and ammonia.**
- **Synthine process by-products given closer consideration.**
- **Prospects dim for new entrants in petroleum chemicals field.**

Technical Data Available Now on Allyl Alcohol

IN THESE days of increased attention to the technical teachings of the past, with consequent emphasis on the preparation of adequate literature searches and summaries, it is interesting from even an academic viewpoint to note the trend toward release of such information by commercial organizations as part of their technical service programs.

Such a release is the recent book on allyl alcohol[1], prepared by the Shell Development Co. which points out that "allyl alcohol has been known to science since 1856," although its standard method of synthesis was based on glycerol until the recent Shell development of the process in which, "by high-temperature chlorination, propylene can be converted into allyl chloride, from which allyl alcohol may be obtained by acidic or basic hydrolysis.

"Allyl chloride, allyl alcohol, and a variety of related compounds have found increasing use in the chemical, resin, and pharmaceutical fields in recent years, and the chloride and alcohol and several of their derivatives are in large-scale commercial production"—by Shell itself, as mentioned previously in this series.

The book contains an introduction, an extensive and documented review of the chemical properties of allyl alcohol, numerous charts and tables of physical data, a discussion of biological properties (toxicity, etc.), an account of specifications and test procedures, a bibliography of 488 references, a usable index, and an interesting chart of the chemical properties of allyl alcohol.

In connection with this subject, it is pertinent to note that a recent technical discussion has been published[2] on the "Commercial Scale Manufacture of Allyl Chloride and Allyl Alcohol from Propylene." There is little question that allyl alcohol will become an increasingly important "chemical from petroleum"—its use for the synthesis of resins alone bids fair to confirm this, and the related synthesis of glycerol itself, soon to be put into commercial operation by Shell, will add to the utilization of allyl alcohol.

(1) Anon., *Allyl Alcohol*, Shell Chemical Corporation (San Francisco), 1946, 95 pp.

Office of Bibliography For Nation is Proposed

WHILE on the subject of technical information, it may be of interest to note some recent remarks of H. F. Willkie (Joseph E. Seagrams & Sons, Inc.), made in a recent address on "Coordinated Research."[3] After stating, "I believe that a post of Secretary of Research in the President's Cabinet should be set up," and discussing functions of such an office, Willkie remarked that such a Secretary "should direct the establishment of a National Office of Bibliography for the purpose of exploring all printed results of research in English and other languages, cataloguing material, translating and abstracting where necessary, and issuing an annual index of catalogue to all libraries, universities, and industrial research laboratories.

"The scope of this project should be as broad as our culture. It should include all the arts, languages, sciences, history, medicine, industry, agriculture, and commerce. It should be designed to collect and disseminate materials which will give Americans a sense of perspective regarding their own cultural and economic history, their present status, and their destinies. While it would be of great service to all industrialists, administrators, university professors, researchers, and technical workers, it should also supply a vast amount of material which could be read and appreciated by millions of plain citizens, ordinary men and women who, at present, depend for their education upon inadequate schooling, biased journalism, sensational films, and superficial magazines. This important voting group now makes haphazard decisions, vital to national and international welfare, without regard or access to the scientific method of determination.

"A National Office of Bibliography would be of inestimable value to Congress and to administrative bureaus."

(2) Fairbairn, A. W.; Cheney, H. A.; and Cherniavsky, A. J., *Chemical Engineering Progress* 43, No. 6, 280 (1947).

(3) Willkie, H. F., *Chemical Engineering Progress* 43, No. 6, 12 (1947).

"Chemical Facts and Figures" Of Considerable Utility

STATISTICAL compendia are the economic meat separated from the voluminous fat and grisle of industry and government surveys and releases. In the petroleum field, for example, the recent *Petroleum Almanac*[4] is almost the last word for reliable statistics available up to its date of issue, serving as an admirable supplement to the prewar Facts & Figures books issued biannually by the American Petroleum Institute.

In the chemical industry, now closely allied to petroleum processing by virtue of the growing manufacture of chemicals from petroleum, considerable importance was attached, in 1940, to the issuance of a similar book[5] by the Manufacturing Chemists Assn. Intended, apparently as the first book of an annual series, this volume presented most of the available statistics not only for 1939 but also for the preceding 10 years.

As for the API series, the intervention of the war prevented the appearance of whatever additional volumes were planned. Now that "wartime restrictions of government agencies regarding release of statistical data in the chemical and allied products fields" have been removed and "most of the figures officially released," a second edition of Chemical Facts & Figures[6] has been released, taking up, in general, where the first edition left off and including statistics from 1940 through 1945, "with some data also in-

(4) Anon., *The Petroleum Almanac*, National Industrial Conference Board (New York), 1946. 420 pp.

(5) Anon., *Chemical Facts & Figures*, First Edition, Manufacturing Chemists' Association (Washington), 1940. 219 pp.

(6) Anon., *Chemical Facts & Figures*, Second Edition, Manufacturing Chemists' Association (Washington), 1947. 401 pp.

cluded for the first six months of 1946."

It would be impossible to summarize in a few words the groups of statistics of interest to the petroleum industry; it must suffice to note such groups of tables as those on nitrogen production and ammonia plants, synthetic organic chemicals, synthetic resins and plastics, synthetic rubber, alcohol, etc.

Future statistics of chemicals' production will almost certainly not fall along the smooth projections of curves of their past records, but such projections, interpreted in the light of expected technical and economic developments, are the only quantitative guide of any real significance.

Hydrogen Cyanide from Carbon Monoxide and Ammonia

ACCORDING to a recent article[7] "it is understood that at least one large plant is actually operating a continuous process making hydrogen cyanide from ammonia and carbon monoxide." While no company name is mentioned, this report, if true, may well be linked with du Pont, since that company is known to have obtained numerous patents on such a process.

A survey of du Pont patents, made in 1941 for the preceding five-year period, showed several du Pont methods for accomplishing the requisite process steps. Usually, the first step involves the reaction of methanol with carbon monoxide to yield methyl formate, then conversion of the latter to formamide by reaction with ammonia (effected, according to du Pont patents, either at atmospheric pressure and 10-60° C. or 50-500 psi at 130° C.). German Patent 624,508 (owned by du Pont), however, describes a combination of both these steps by reacting carbon monoxide, ammonia, methanol, and sodium methyl alcoholate at 75° C. and about 17 atm. pressure, 95% yields being obtained.

Hydrogen cyanide is then obtained by dehydration of the formamide, effected, according to du Pont patents, at 550-630° C. over a film of Zn, Al, Mn, Cr, or Sn oxides (U. S. 2,042,451); at 400-700° C. over fused MnO (U. S. 2,086,-507); or at 250-400° C. over various dehydrating catalysts (British 469,563; 470,406).

Interestingly enough, du Pont also possesses numerous patents on the direct synthesis of hydrogen cyanide by reaction of nitrogen compounds (ammonia, nitrogen oxides, etc.) with hydrocarbons (methane, ethane, etc.) in the presence of air and catalysts. Very high temperatures are required, incidentally (800-1500° C., preferably 1100° C. and above).

(7) Burrell, H., *Chemical and Engineering News* 25, No. 27, 1939 (1947), "Hydrogen Cyanide from Carbon Monoxide and Ammonia."

Returning to a discussion of the formamide process, Burrell reports that the I. G. Farbenindustrie used it in Germany to produce nearly 460 tons of hydrogen cyanide per month; the process used involved reaction of carbon monoxide with methanol at 150 (increased slowly to 3000) psi. and 100° C. in the presence of sodium methylate; reaction of the methyl formate with ammonia at 40° C. and about 200 psi.; and (details here are sketchy) dehydration of the formamide over activated alumina at 200-300° C.

This process and important German uses for hydrogen cyanide are described in three reports of the Office of Technical Services, PB 44,962, "Formamide Production"; PB 5,077, "Hydrocyanic Acid"; and PB 952, "Acrylonitrile." Commercial interest in this country centers around the fact that cheap hydrogen cyanide means less expensive nylon, glycols and glycol derivatives, fumigants, pigments, etc. Hydrogen cyanide is also used in the extraction and electroplating of gold and other precious metals.

The formamide process of hydrogen cyanide synthesis is at least of academic interest to the petroleum industry in that it constitutes another method of producing an important chemical from petroleum or natural gas, ammonia, methanol, and carbon monoxide being so produced in quantity at present.

Synthine Process By-products Given Closer Consideration

GEORGE R. Benz, manager of Phillips' Chemical Products Department recently told the American Gas Association, in a paper on "Liquefied Petroleum Gas, Supply and Demand Outlook," that "a factor of significance to the future supply (of liquefied petroleum gases) is the increased interest in modifications of the Fischer-Tropsch (Synthine) process for converting dry natural gas into motor and diesel fuels, *liquefied petroleum gas,* and alcohols. One process can produce about 66 gallons of LPG per 1000 gallons of motor fuel. Two plants are planned . . . . having a reported combined motor fuel capacity of 12,000 b/d."

The above-mentioned ratio seems low in the light of a statement of J. H. Forrester, manager of manufacturing for Stanolind Oil & Gas Co., that his company's projected Synthine ("Synthol") plant, scheduled for production in 1949 in the Hugoton field in Kansas, will daily produce 5300 bbls. of gasoline, 800 bbls. of fuel oils, 1060 bbls. of light hydrocarbons, and a half-million pounds of chemicals.

J. E. Latta of Stanolind, in discussing the chemical by-products of the Synthine process, states that "the oxygenated compounds formed are a potential source of large quantities of valuable organic chemicals. These materials are useful in various fields as solvents, anti-freeze preparations, and raw materials for the manufacture of fine chemicals. Included are alcohols, ketones, organic acids, and aldehydes, many of which have widespread use."

In a recent speech before the Kansas City Section of the American Chemical Society, Scott W. Walker of Stanolind stated that each of the two Synthine plants would produce about 360,000 pounds of crude, water-soluble chemicals per day, most of them found in the water stream from the oil recovery section, although the oil stream contains additional oxygenated chemicals, of four or more carbon atoms, of "less importance industrially at the present time since their availability is limited."[8] As mentioned in the June installment of this series,[9] ethyl alcohol predominates among the alcohol by-products, which in turn are the major fraction of the entire by-product stream.

Dim Prospects for New Entries In Petroleum Chemicals Field

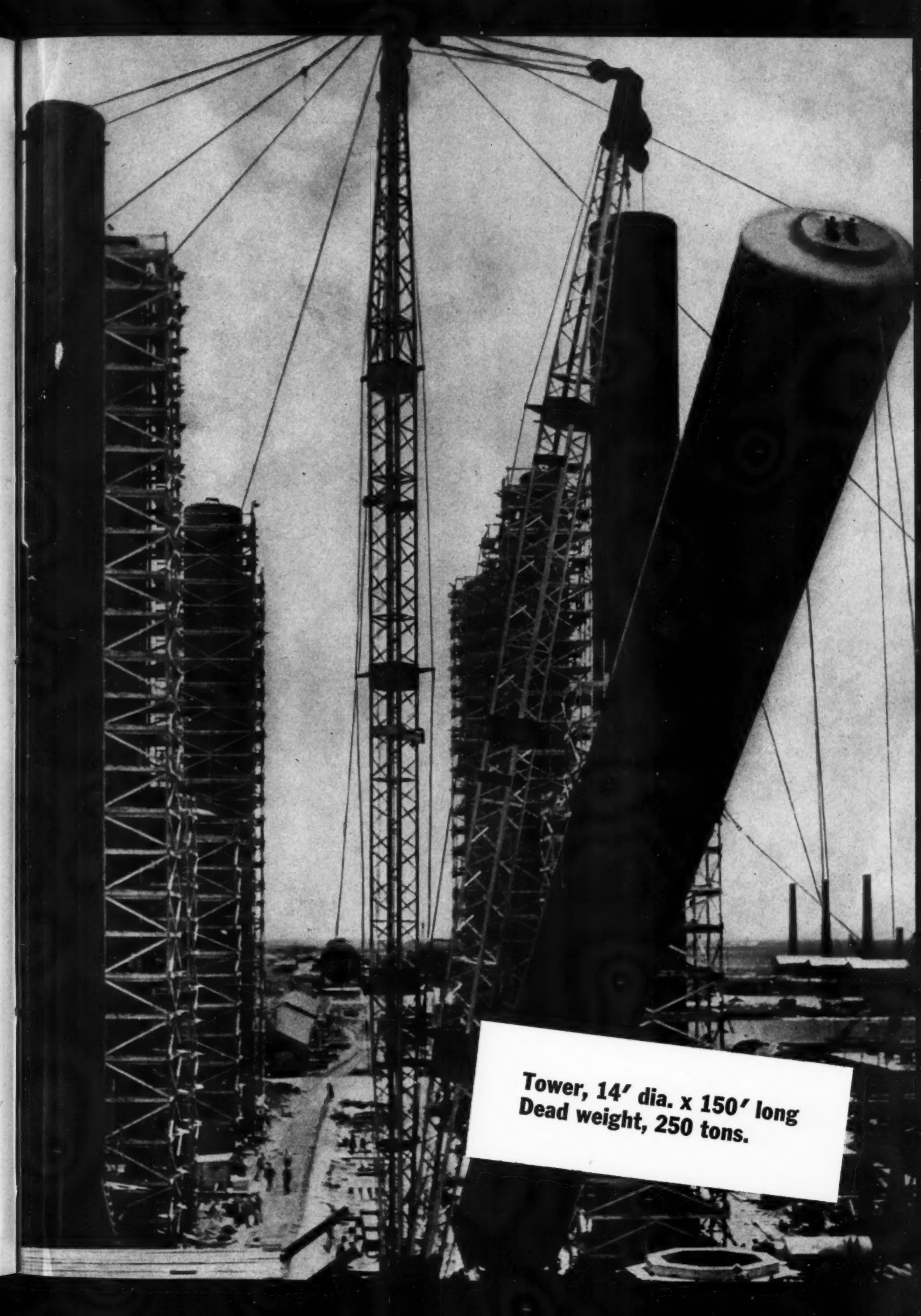
ACCORDING to a report[10] of a speech entitled "Is it Too Late for the Leaders in Petroleum to Lead in Chemicals," Bradley Dewey, former Rubber Director and now president of Dewey & Almy Chemical Co., recently told the Fifth Joint Technical Meeting of the Standard Oil Co. (Indiana) that "it is too late for the petroleum company which does not have an enlightened management to enter the chemicals field. . . . . Not only must the management be enlightened, but the technical men have a job to do in leading it to the right answers. They must know all the facts, have a program, and present more than chemical reactions, heat balances, and costs. . . . ."

The oil companies hold the advantage in the availability of raw materials and supplies, in their buying power, geographical distribution, knowledge of crudes, processes, by-products, and trends, as well as in freedom of action over some, but not all, chemical companies. As for production and operating ability, Mr. Dewey placed oil and chemical companies on a par. Chemical companies, on the other hand, have more flexible philosophies, move faster, will take much longer risks in developing new products and markets for them. They have a distinct edge in their abilities to judge markets for products made from materials they plan to sell.

(8) Anon., National Petroleum News 39, No. 26, 44 (1947), "High By-Product Recovery Seen in Synthetic Plants."

(9) Anon., Petroleum Processing 2, No. 6, 409 (1947), "Tomorrow in Petroleum Technology—Petroleum Synthesis to Dominate Alcohol Field."

(10) Anon., *Chemical and Engineering News* 25, No. 22, 1582 (1947), "Dewey Appraises Oil Companies' Chances in Chemicals."


Tower, 14′ dia. x 150′ long
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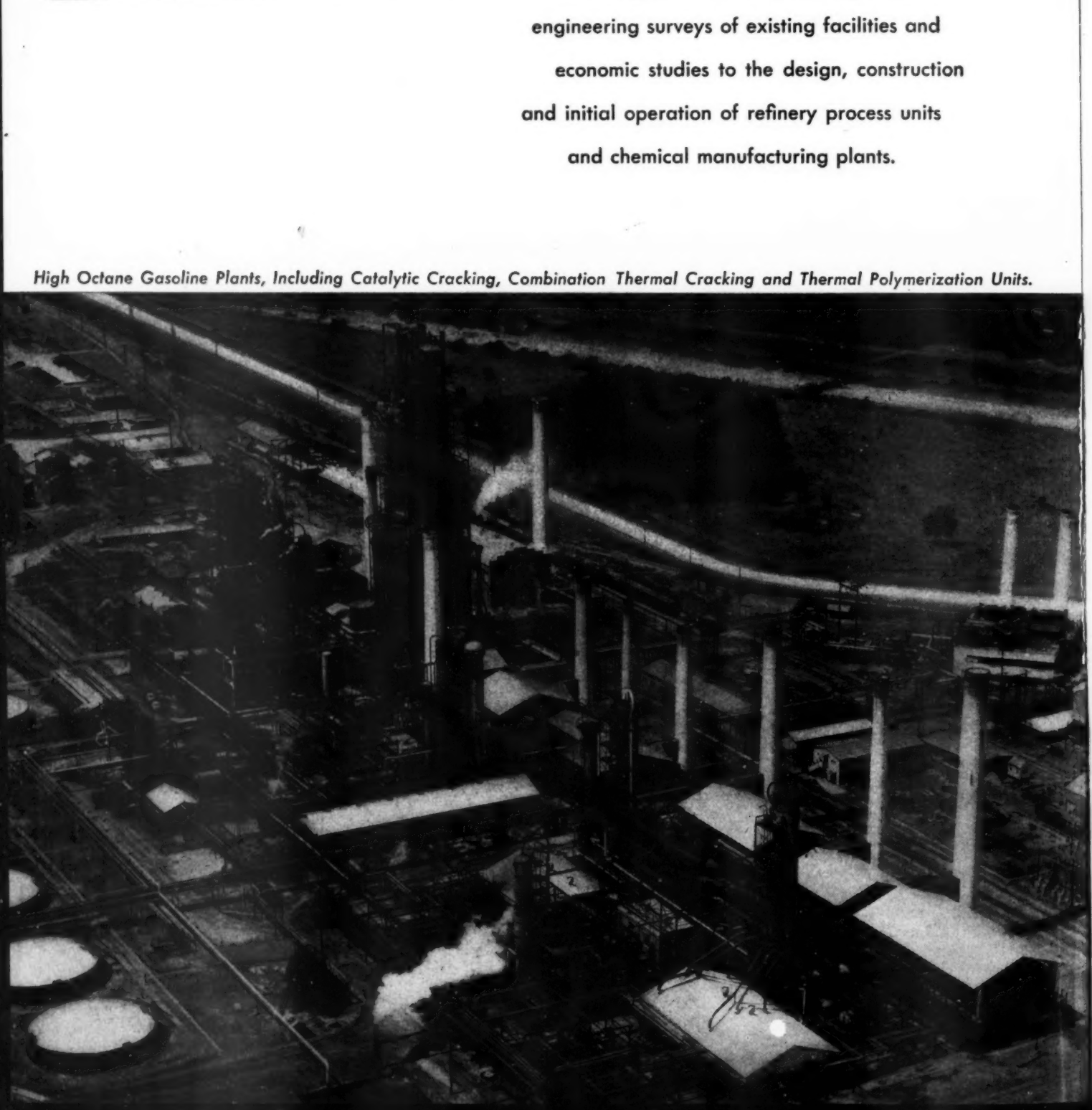


PLANT PRACTICES

Practical Tips and Ideas for Improving Refinery Operations

Store and Tool Rooms on Wheels Save Time And Paper Work in Refinery Turnarounds

USE OF two big gray truck trailers converted to portable tool and store rooms has contributed gratifying savings in time and clerical costs on unit turnarounds at the Wood River (Ill.) refinery of Shell Oil Co., Inc. because tools and materials are right on the job and available when needed.

In addition to eliminating the extra trips by maintenance men back to central stores department for needed articles and tools, the portable units make impressive economies in the paper work by concentrating the accounting procedures on one job at a time.

In one six weeks' trial period, the store room on wheels served four shutdowns totalling 20 working days. In that time it filled nearly 1100 individual orders that accounted for 92% of all materials used on every job. The trailer clerk draws material from central stores on a general plant account and issues it to workmen on the job without order forms.

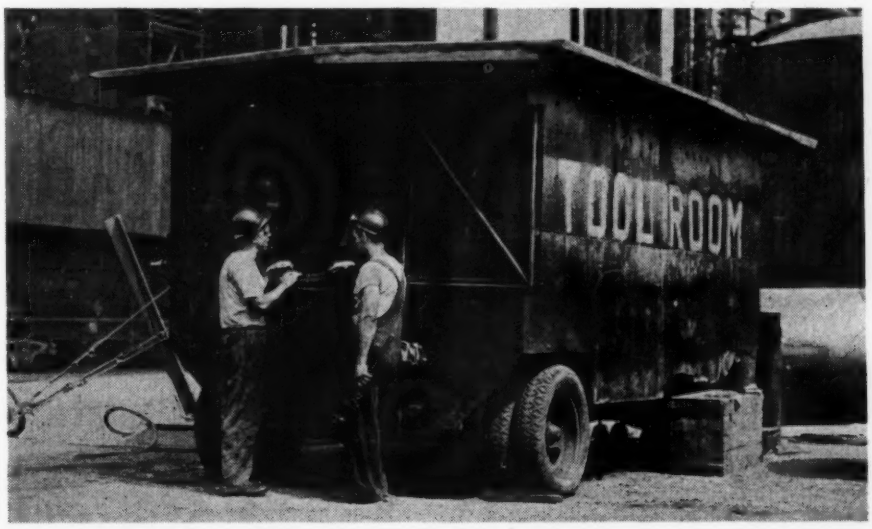
The portable store room carries a supply of materials most likely to be required by the various craftmen on the particular unit turnaround to which it has been assigned. Close cooperation between the Engineering and Stores Departments' supervisors is necessary to analyze the job and assure that the "run of mine" type of materials required will be in stock in the portable store room when it is moved to the job site.

The portable tool room has proved also to be a valuable adjunct on a unit shutdown. In this vehicle all of the ordinary handtools likely to be required for the job, both routine and specialized, are carried. Also included are such items as safety goggles, respirators, gas masks, protective clothing, and the like.

The portable store room is equipped with direct telephone service to the main stores department, lines being connected on each job. Both store and tool rooms are equipped with electric lights, fan, steam coils, and all other items essential to the comfort and convenience of the attendants.

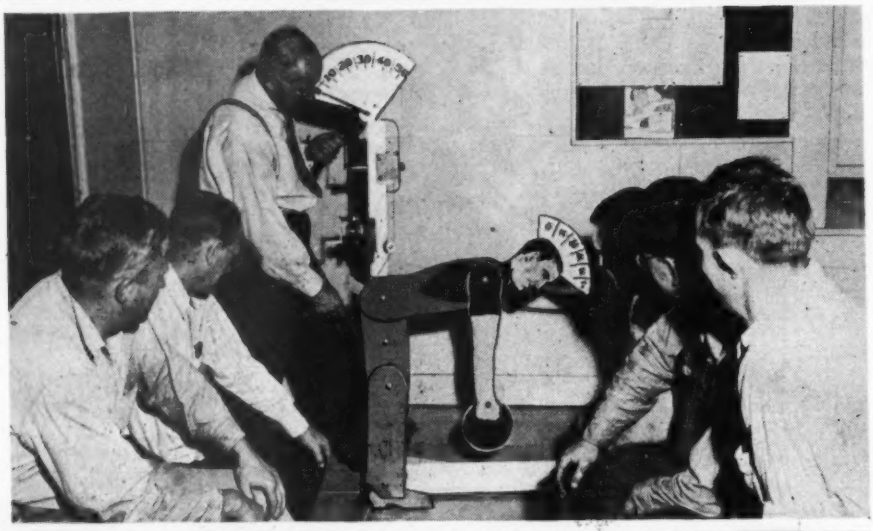
The tool room was built in Shell's shops, whereas the store room was built by a St. Louis body company at a cost of approximately $5000. Commercial chassis were used in each case, and the bodies constructed to meet Shell's designs and specifications. The interior fixtures consist essentially of cabinets, bins, and desk filing facilities for handling the clerical work.

Shell plans to build more for other refineries.



RIGHT—(Above) Portable tool room, built in Shell Oil Co.'s Wood River refinery shops, carries all ordinary and most special tools used for maintenance and repairs on unit turnarounds. RIGHT—Portable store room was custom built for Wood River refinery. Like the tool room, it carries routine and special materials needed on the job. Both trailer units are towed to various locations by truck

Back Injuries Drop When "Louie the Lifter" Puts on a Show



TOP—California Standard's safety engineer introduces his class to "Louie the Lifter" explaining how Louie will put on his little demonstration. MIDDLE— Louie shows bad form in lifting, the easy way to get a strained back because all the lifting force is being placed on his back muscles. BOTTOM—The class sees how to do it correctly, using the husky muscles in the shoulders and thighs and relieving the back entirely of any strain

LOUIS the Lifter is a mechanical robot built by the safety division of Standard Oil Co. of California. He goes around to various plant safety meetings and classes and puts on a show demonstrating how to "break your back" lifting heavy objects and how to save your back performing the same task.

Plans for a similar robot used by Bethlehem Shipbuilding Corp. were secured and "Louie" was designed and built stronger so as to be more suitable for moving about in the field by safety engineers.

As shown in the photographs and described by the safety men, the action of the pulleys and cables on the nearly life-sized figure is about as follows:

The indicators on the two sets of scales are attached to cables representing certain muscles. The cables pass over pulleys which represent certain body points used more or less as fulcrums when the body is lifting.

The machine can be operated in two ways—first the body can be bent over at the waist so that when the man is down to his load and ready to lift, his legs, back, and arms represent three sides of a rectangle. When he starts back up, his muscles are all pulling in an unnatural way. The leg muscles cannot be used and the whole strain is thrown on the muscles just over the pelvis with no leverage from anywhere to help. In this position the front indicator shows all the load on the back and none on the rest of the body.

In the second position, the robot can be lowered to represent a man getting down to his load the correct way—his legs bent and his back in a straight line. When he rises in this case, the load registered on the back indicator, which represents the leg muscles, will show that by far the largest part of the load is being lifted by the thigh and shoulder muscles and the strain on the back muscles is negligible.

IDEAS—Wanted!

Plant operators, foremen, superintendents:—Send in your own original contributions on "how we do it around our refinery." Possible subjects could include operating shortcuts, time and money-saving gadgets, repair ideas, accident and fire prevention schemes. Include if possible photographs, drawings or graphs.

The idea's the thing—so send it in to:

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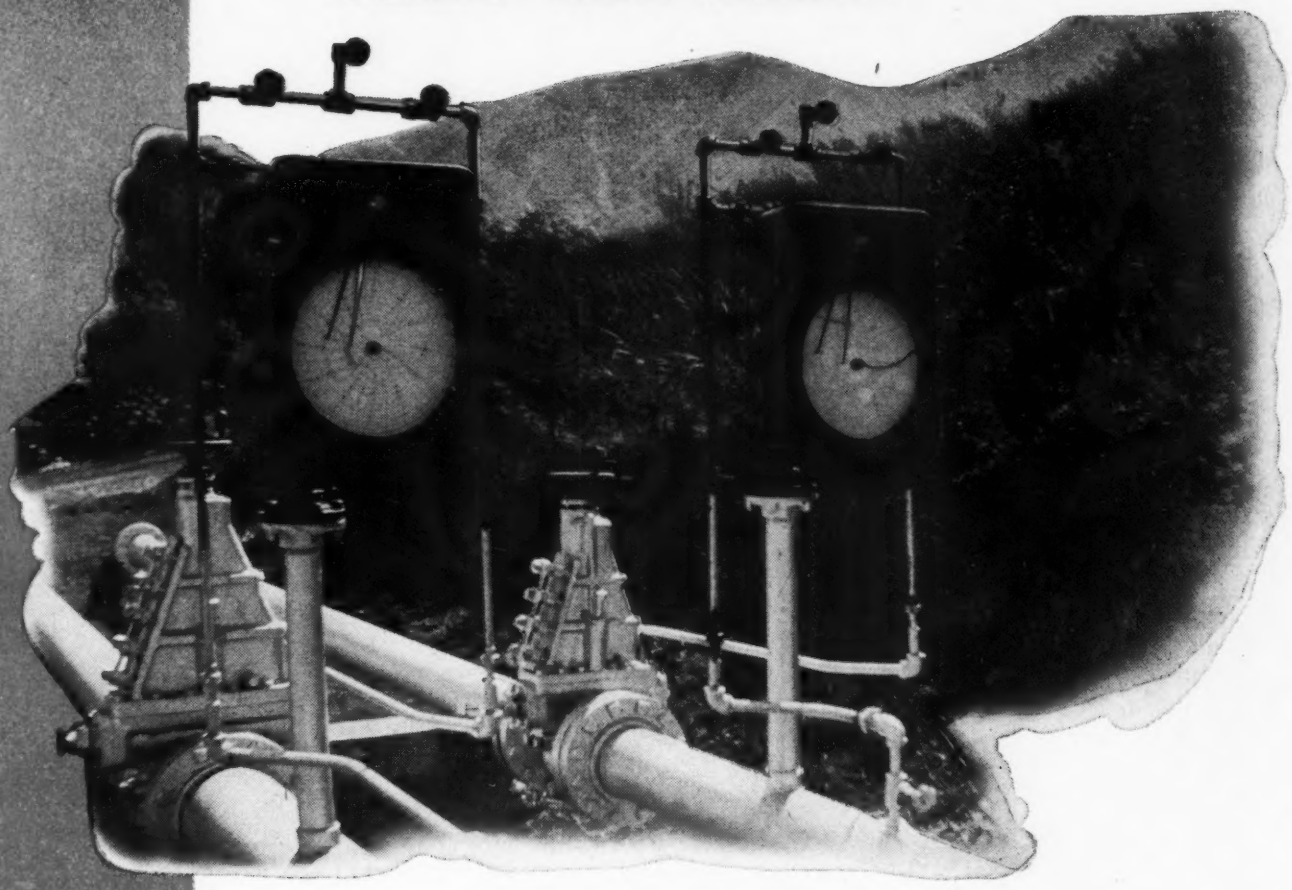

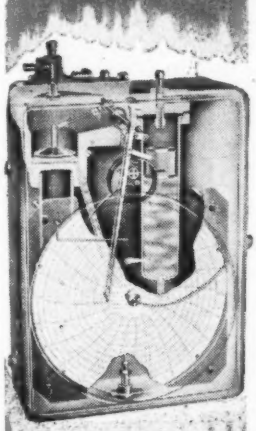

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Clay Levels in Hoppers Shown Instantly And Controlled by Electrical Instrument

By ALFRED KRIEG, Supervisor, Instrument Department
Socony-Vacuum Oil Co., Inc., Paulsboro (N. J.) Refinery

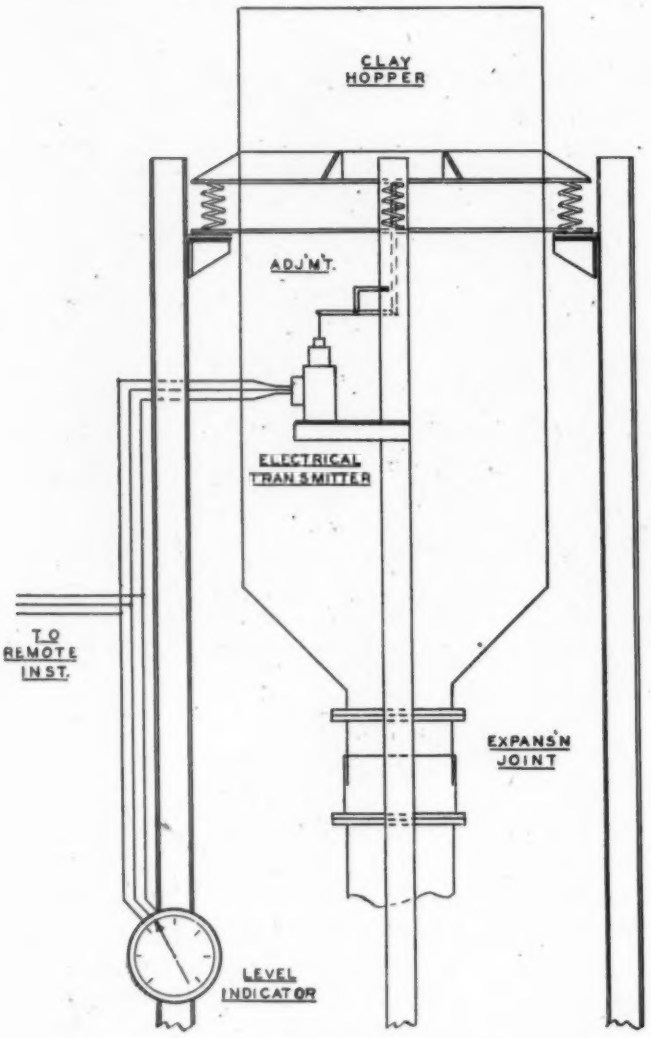

Fig. 1 — Electrical device for indicating clay level in hopper. Variations in clay quantities effect varying downward forces against coil springs and corresponding motion in link connection to transmitter armature

SOLIDS level in bins and hoppers are indicated instantaneously by an electrical device which measures the proportional degree of downward travel of the container caused by variations in the quantity of material. Developed by the Instrument Department at Socony-Vacuum's Paulsboro refinery, the method is shown in Fig. 1.

The clay hopper is supported at the reinforced hopper ring by four heavy springs mounted on the support arms of the vertical beams. An expansion joint at the bottom of the hopper permits free movement of the hopper in a vertical direction.

The springs supporting the hopper must be of sufficient strength to support the combined weight of hopper and material. They must also have suitable compressibility characteristics to give a proportional degree of travel for each increment of load change.

A conventional electrical transmitter of the inductance coil type is mounted on one of the rigid vertical columns. A short rod attached to the hopper ring is connected to an armature through linkage which is adjustable at the fulcrum to give a 1.2 in. range of travel of the armature from zero to maximum travel of the hopper.

Each position taken by the armature in the coil of the transmitter is electrically transmitted to a receiver where the deflection is converted to a level indication.

The device operates as follows: Clay from a kiln passes through the hopper and out of the bottom at such a rate as to maintain a given level of clay within the hopper. The zero setting on the indicator is made with the hopper empty. As the clay level in the hopper increases, the weight causes proportional uniform compression of the springs, and downward movement of the entire hopper. This downward motion of the hopper causes the armature in the coil to move likewise by means of the connecting linkage.

If it is desired to record or control the clay level, the indicator may be replaced by a recording or control instrument. The controller may be designed to control the rate of flow either from or to the hopper by operating an appropriate throttling or regulating device.

Reduce Pump Packing Repairs By Babbitt Lining in Glands

By J. W. MAY
Phillips Petroleum Co.

SOURCE of recurring damage to pump rods is scoring which results from rubbing contact with the packing gland when the latter is unevenly tightened. Shafts equipped with packing glands are susceptible to frequent maintenance for the same reason. Lining the packing gland with a thin layer of babbitt metal will prevent this.

The babbitt need be no more than about ⅛ in. thick. In the particular application described, the lining was applied to the gland on the fluid end of a 16 x 9 x 18 steam-driven pump. Cost was $5.00 for labor, machining, and babbitt metal.

The gland was 6 in. long, 4 in. O.D., and 3 in. I. D. First, a ⅛ in. cut was taken from the inside all the way through, leaving the I. D. 3¼ in. Then grooves were cut to lock the babbitt in place. Two of these were lengthwise and on opposite sides. The others were cut around the circumference at each end of the gland. They were about 3/32 in. deep and 3/16 in. wide.

The inside wall of the gland was then tinned, and a 2½ in. shaft placed through the center. Babbitt metal was poured in the form produced by the space between the gland and the shaft. This was then machined down to the original 3 in. I. D. of the gland, leaving a ⅛ in. babbitt lining locked in place.

An experimental installation on a raw feed pump at a gasoline plant is estimated by company engineers to save two sets of packings a year and one piston rod every two years. It was noticed immediately upon installation that the babbitt-lined gland was easily tightened and still permitted smooth operation of the pump. The rod, already scored at the time of installation, was not scored further.

On other installations, with smooth rods, it has been proved that scoring from packing glands can be eliminated. It is understood, of course, that the life of packing and rods may vary considerably due to the skill of pump repairmen and operators making the adjustments, proper pump alignment, and speed at which the pump is operated.

A CONTEST

What's Wrong in This Picture?

A new transfer line was being installed. The shop-fabricated pipe tee, however, was found to be off-center and had to be moved. Rather than holding up the job by sending the pipe back to the shop, plant welders were called to change it on the site. They set up their equipment and started to work. But according to Bill Smith, safety engineer for Standard Oil Co. (Ohio), they may never have finished. He finds them doing at least 12 things which violate good welding practice and common safety rules. Can you find as many? (Ed. Note: Don't condemn the welders shown here; the picture was posed for PETROLEUM PROCESSING's staff photographer.)

Welding Handbooks Given for the Best Answers

PETROLEUM PROCESSING will give a copy of the "Procedure Handbook of Arc Welding Design and Practice" to each of the ten readers who send in the most complete list of "WHAT'S WRONG" with the way these welders are doing their job.

This offer is being made to stimulate interest among PETROLEUM PROCESSING's readers in correct safety practices. It is our opinion that such practices are as essential to efficient refinery operation as good equipment and maintenance, and that anything we can do to promote them will be of benefit to the petroleum processing industry in general.

There are no restrictions on the number of words you can use or the method in which you present your list. The rules are simple:

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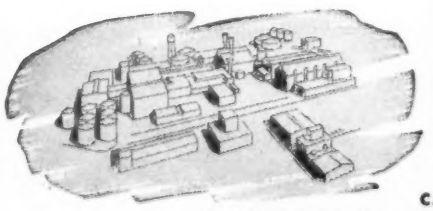

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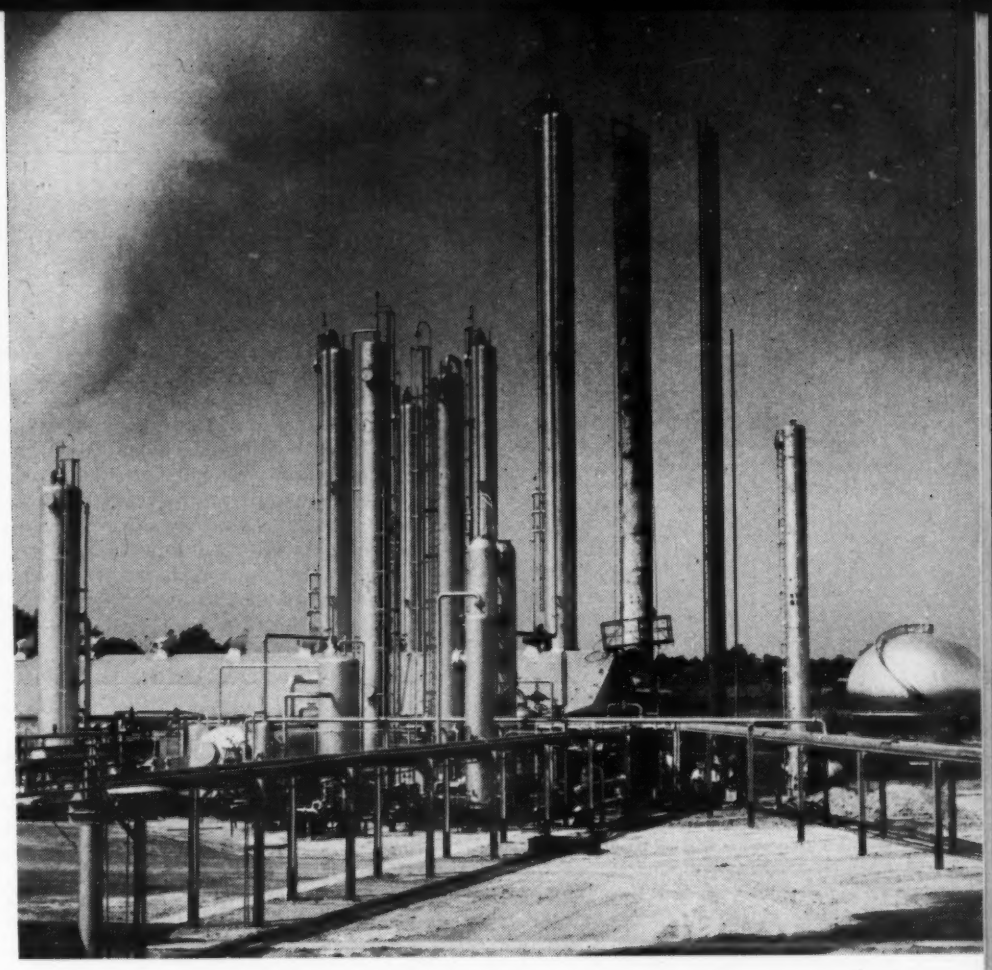

Hawkins, Ill., plant of Warren Petroleum Corp. has seven-column fractionionation battery, produces pure propane, i- and n-butane, i- and n-pentane, hexane and heptane fractions and 7-lb. bottoms

Increasing Propane Recovery In Existing Gasoline Plants

By D. P. THORNTON, JR.,
Assistant Editor, PETROLEUM PROCESSING

The increasing economic importance of propane today for LPG and as material for manufacture of chemicals has focused attention on improving means for its recovery in natural gasoline plants. General practical aspects that must be considered in modernizing existing plants to this end are presented. Studies of changes required in three typical designs of natural gasoline plants are given, and the cost factors involved are discussed. It is recognized that methods actually adopted and their cost will depend on conditions in the individual plant.

THE increased attention being given to propane as the fair-haired child among the light liquid hydrocarbons has turned the engineering of natural gasoline plants in the direction of increasing its recovery from the gas processed, without unduly sacrificing yields of butane and other products. In some instances straight refineries are considering installation of equipment to extract the approximately 2% of propane in their crude which is now being used as plant fuel.

Moderate changes in operations and equipment in some existing gasoline plants have made possible the recovery of up to 80% of the propane present in the gas. Until recently these older plants, some of which were modernized during the war for 90 to 95% butane yield, were recovering anywhere from 5 to 30% of the available propane as an incident to high butane recovery. Entirely new gasoline plants are being designed for up to 80% propane recovery.

All indications are for a continuance of the relatively new large demand for propane, which will encourage even greater attention in plant design to a high rate of yield of this product. The advantages of propane over butane for Liquefied Petroleum Gas are receiving greater recognition. In cold climates provision for pre-combustion vaporization is not required where propane is used, but is necessary for butane because of its higher boiling point. Of total LPG sales in 1942, 26% was propane; in 1946 propane represented 43% of total LPG sales[1]. Production of propane the first two months of 1947 was 83% greater than for the same period in 1946, according to the same authority. Propane is more valuable to the chemical manufacturer than butane since it is readily cracked at high yields into ethylene for further synthesis into a variety of products.

In view of these conditions, owners and operators of many existing natural gasoline plants are asking how they can boost their present propane recovery, or provide the means for extracting it for the first time. The remainder of this article is given over to this phase of the subject. Unfortunately, there is no one-shot method by which either propane or butane recovery can be increased. What will work satisfactorily in one plant may be useless, or even worse, for its neighbor.

Modernization costs for the individual

plant may range from a few thousand dollars to more than the original basic plant investment, depending on the design of the plant and the extent of propane extraction which is desired. In general increasing propane yield is more expensive than for boosting butane make and for many plants may become economically prohibitive for recoveries above 50 to 80%. In such instances, as one engineer facetiously suggested, it may be cheaper to throw the old plant away and start over.

Requirements for C_3 Yields

In general, propane recovery requires an absorber operated at sufficient pressure to extract the hydrocarbon, and a de-ethanizer for its purification, plus appropriate pressure storage. If the plant does not already have a depropanizer—unless propane-butane mixture only is to be recovered off the existing stabilizer—this tower will also be necessary. In either case it is doubtful that substantial propane recovery can be secured without some changes in the existing absorber and auxiliaries. Likewise, the fat oil still may require alteration and perhaps these changes will require alterations in much of the balance of the distillation section to handle increased loads.

In plants which already are recovering in their stock tanks some part of the propane in the wet gas, it is often possible to materially increase propane recovery by relatively minor changes. Often, the major bottleneck is found to be inefficient use of existing columns.

In exceptional cases, the solution to the problem may be the installation of an additional absorber and still, plus a de-ethanizer, to operate on the residue gas from the plant. This usually will not be at a low cost, since the absorptive effect of the heavier hydrocarbons already condensed out is lost, requiring a very high oil circulation and high pressures for reasonable recoveries.

Before any attempt is made to determine what design changes (other than efficiency improvement) in an existing plant are necessary for increased propane recovery, the first step is to determine, by analysis and calculation, how much propane is present in the wet gas, how much is being extracted by the absorber and how much is left in the residue gas. Next the market for the product available *to that plant*, in competition with its neighbors, must be evaluated.

In this connection, how much increased propane recovery will change the setup on present plant products must be estimated. For example: Can the gasoline be marketed without a price penalty if all the propane is removed? Will a pentane splitter be required, removing n-pentane to keep the gasoline octane number at the desired level if all propane is separated? If some propane must be left in the gasoline for a salable product without pentane splitting, will the remaining quantity of propane be worth recovering?

From these calculations it then can be determined what sum can be spent for modernization with a reasonable pay-out (two to five years usually, on the additional investment). When this last question is answered an engineering study of the plant is in order to determine if the sum anticipated from the additional propane will buy what is needed or if worthwhile compromises can be effected.

This article will only attempt to describe what steps can be taken under assumed conditions in whole or part applicable to the usual type of plant encountered in the southwest. The writer acknowledges indebtedness to numerous gasoline plant engineers and designers who contributed generously with their ideas and time in discussing the subject.

Theoretical Considerations

The ordinary plant, absorbing at 50 psi, cannot hope to recover any worthwhile quantity of propane without at least doubling absorber pressure. At the same time, an absorption pressure in excess of 800 psi is not practical without other radical changes in the plant because of the phenomenon of retrograde condensation which, in the range of 800 to 2000 psi, would tend to throw butane and heavier hydrocarbons back into the gaseous phase.

Ordinarily, an increase in pressure (below 800 psi) on the absorber will tend to increase the amount of hydrocarbons absorbed. This in turn may permit an actual decrease in the plant's existing oil rate, assuming it was originally designed for, say 50 psi.

Another factor must be considered, however, which further limits the permissible pressure increase. In the usual design of a de-ethanizer, operation above 500 psi quickly approaches a point where steam required for adequate stripping becomes so high as to demand extensive revamping of a plant's boiler capacity, if not prohibitive for other reasons.

Yet another factor which must be carefully evaluated in revamping a given plant is the increased vapor load on the distillation section which automatically occurs with increased extraction of either propane or butane. If propane recovery alone is to be doubled for instance, it may be expected that the amount of methane and ethane also extracted will be doubled.

Remove Bottlenecks

In general, in the following discussion it will be assumed that in the plant as revamped, maximum pressure to be encountered does not exceed 500 psi.

First considerations should be the elimination of existing bottlenecks in the existing plant, and determination of the extent to which present fractionation columns are loaded. If present columns are loaded to capacity, any increase in hydrocarbons extracted will mean additional columns throughout the plant.

Ordinarily this is not encountered in gasoline plants since few operate even at design loads for more than a few years after they are built. This is the chief factor permitting increased extraction efficiencies. Cycling plants, on the other hand, usually are still operating with heavily loaded columns. Hence, a new product facility may require extensive equipment installation ahead of the "old" distillation section to handle the increased vapor load. In some cases this may be accomplished by installation of a de-ethanizer, increasing oil rate (or refrigerating it) and alterations to the still and accessories for greater vapor capacity.

Tests often reveal an excessive pressure drop between still and accumulator. This normally should be of the order of 5 psi or less. Increasing the size of the vapor transfer line and reducing temperature of the liquid in the tank by means of additional cooling surface (not necessarily by the addition of some form of refrigeration) may increase light ends recovery 5 to 10%. Use of as low a molecular weight of absorption oil as facilities to transfer columns not suitable in the impurities as sludge, dirt, heavy ends from compressor lubricant and crude entrained with a raw gas are important also[2].

A great many plants apparently have loaded or overloaded columns which in fact are either improperly controlled or inefficiently designed, one engineer states.

As a case in point, he mentions one plant formerly able to operate at only 70 or 80% of original design. Inspection of the distillation section revealed excessive hydraulic gradient in one tower. This difficulty was eliminated by removing nearly half of the bubble caps and resulted in the column showing a capacity of considerably more than 100% of design.

In another plant, the offending column was found to have trays so closely spaced that design throughout could not be reached and maintained without considerable liquid entrainment in the vapor ascending the tower. In such a situation, some relief can be obtained by removal of alternate trays, although this inevitably is accompanied by a simultaneous decrease in the degree of fractionation possible with the reduced number of actual trays. Depending on tower design and other changes which may be contemplated in the plant, it may be possible to transfer columns not suitable in the proposed operation to some other not-so-critical service rather than to discard them entirely.

In any plant it may be possible to sharply increase the capacity of a given tower without changing the design of preheater, reboiler or reflux condenser by paying proper attention to location of the feed point and the extent of vaporization in the feed entering the tower; in other words, by operating the column at maximum efficiency.

One of the best recent discussions of this subject, although not intended primarily for natural gasoline plants, was

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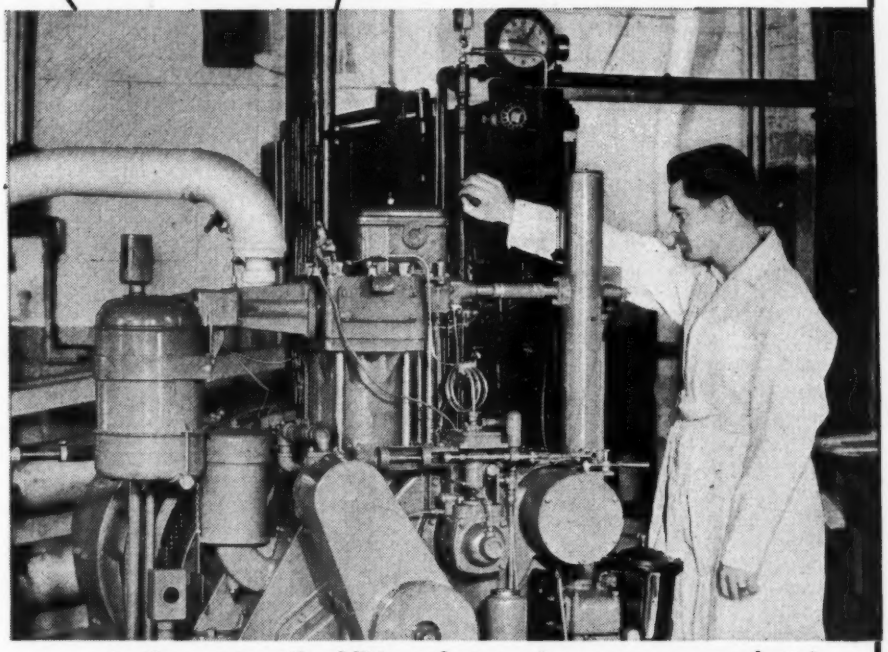

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presented before the American Petroleum Institute last November under the title "Miscellaneous Fractionating Techniques."(3)

This report should be in the data file of every refinery and natural gasoline plant technologist. Examination of a plant in the light of factors such as brought out in this report, data in which is based on a careful survey of many installations by a PAW Technical Advisory Committee sub-committee, may pay dividends in the form of increased production. In the subject at hand, it may reveal the possibility of substantially increasing propane production without the necessity for excessive investment in new equipment.

In considering what will be necessary to increase propane recovery in an existing well-designed plant, consider first three typical designs of natural gasoline plants, designated for convenience as Cases 1, 2 and 3:

Case 1—Absorbers operate at 100 psi, rich oil still at 50 psi; plant makes 26-lb. natural gasoline including extraction of 30 to 40% available butane—no LPG. Desires 95% butane recovery, propane incidental to butane (15-25%), will sell excess C_3-C_4 as LPG mixture.

Case 2—Absorbers operate at 200 psi, still at 50 psi; sells excess C_3-C_4 as LPG mixture. Will sell residue gas to pipeline at 700 psi; increase propane from present 25% to 50% minimum, 80% maximum, sell as butane and LPG mixture.

Case 3—Absorbers and still operate at 200 psi, residue gas to pipeline at 700 psi; recovers 95% or better of butanes, 20% of propane; sells excess C_3-C_4 as butane and LPG mixture. Desires 80% propane recovery, will sell C_3, C_4 and mixtures.

Case I Plant

In Case I, there are three ways in which extraction may be increased, assuming a clean, low molecular weight absorption oil already is in use: namely by increasing oil rate, absorber pressure, or both. (It would be possible also to refrigerate the oil).

If the oil rate is increased, additional heat exchange capacity will certainly be required, as well as greater pump capacity. The still capacity also must be considered. If the absorption pressure is raised without changing oil rate, no changes will be required in heat exchangers. Proportional changes will be required if both oil rate and absorption pressure are increased.

For discussion, assume the oil rate will be increased by one-third and absorber pressure doubled (to 200 psi). The old absorber will be utilized and an additional absorber installed to process tail gas from the first after compression to the higher pressure. An additional pump, taking suction off the existing pump, boosts the oil pressure to 200 psi for the new absorber and coincidentally supplies the required increase in oil circulation. One low-pressure heat exchanger will take care of the additional heat dissipative capacity required.

The existing still will be used. Provision for the increased vapor load is taken care of by installation of a larger overhead vapor line and by doubling the amount of reflux with a new pump in parallel with the old. The old overhead vapor condenser, cooled with 90° F. water, will still be used, and may be backed up by an additional condenser also cooled with water or perhaps propane or butane, which drops vapor temperature to 60° F. (To go lower will invite plugging from ice formation).

It is entirely probable that little or no condensate will result in the accumulator if refrigeration is not applied, and by no means all of the recoverable hydrocarbons will condense even when refrigeration is used. This is because there has been an increase in concentration of the light ends and temperature will not be low enough for equilibrium to result at the temperature and pressure involved. To decide whether or not to refrigerate in an actual case, the two costs must be compared.

In either event, a recompressor will be required, to take suction on the accumulator vapor and compressing to 250 psi, discharging through water-cooled exchangers at 80 to 90° F. into a secondary accumulator.

In this accumulator a large amount of condensate will result. The secondary accumulator vent gas will consist largely of ethane and lighter, with some small portion of propane and butane. It depends entirely on the extent of the loss of valuable hydrocarbons at this point whether or not it will be worthwhile to recover them. In the event recovery is elected, both vent gas and condensate should be refrigerated to perhaps 60° F. or below before venting the gas. Less recovery will occur if gas alone is refrigerated, since the heavier hydrocarbons already condensed will act similarly to absorption oil.

The effect of refrigeration on absorption of the lighter hydrocarbons at 55 psia from a base temperature of 80° F. is shown in Fig. 1(4), which is a plot of lean oil temperature against increased oil absorption. By lowering the oil temperature from 80° F. to 60° F., for example, methane absorption is increased 12.5%, ethane about 18%, propane 26% and the butanes about 28%. Some engineers state that costs for installing refrigeration in an existing plant are approximately half that encountered for increasing oil rate an equivalent amount. Others believe refrigeration has received undue attention for the benefits to be derived.

In the event some condensate should be recovered in the primary accumulator, it should be combined with that recovered in the recompressor accumulator so that the absorptive power of this additional material can be utilized as previously explained.

One design authority suggests that, if all condensate is to be brought to equilibrium at 200-250 psi, it is better not to refrigerate recompressed gas and condensate. There is already an appreciable amount of ethane and lighter dissolved in the condensate prior to refrigeration, he explains. Refrigeration will increase this quantity in direct ratio to the additional propane recovery secured.

The combination thus may require additional de-ethanizer capacity, or require refrigeration of de-ethanizer overhead to finally condense the valuable product, depending on the precise equilibria involved in any specific case. A de-ethanizer pressure of 250 psi is considered optimum for most plants and will come closest to the optimum efficiency of a de-ethanizer

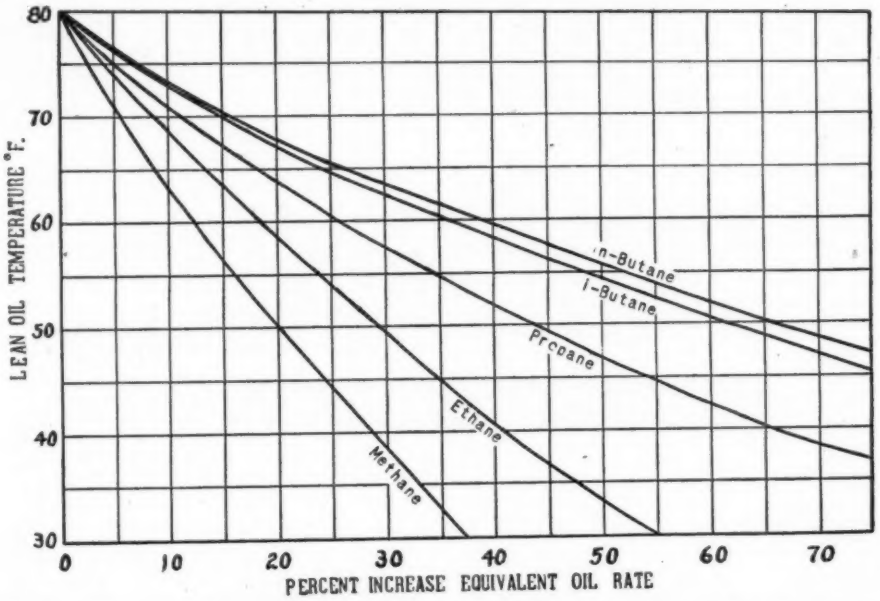

Fig. 1—Effect of refrigerating lean oil on absorption capacity for light hydrocarbons. Data are based on lean oil from coolers at 80° F. and pressure of 55 psia

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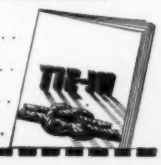

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operating at 450 psi; the latter would undoubtedly require a considerable increase in steam generating capacity for the plant.

Case II Plants

New conditions for the Case II plant must first take into account that all residue gas will be more than tripled in pressure from the original 200 psi when the plant is connected to the 700 psi gas transmission line. Since additional compressor horsepower will be required in any event, it probably will be most economical to add this as additional stages to the original raw gas compressors rather than to increase absorber pressure and also compress residue gas.

If the intake gas pressure is raised to 750 psi, the original absorbers must be replaced by vessels of 800 psi rating. The additional 50 psi over pipeline pressure will compensate for normal pressure drop through the plant. The original oil pump can be utilized as a booster for a new small capacity, high pressure pump. The oil rate probably will not be higher and likely will be less than in the original design, hence no change will be required in the existing lean oil coolers.

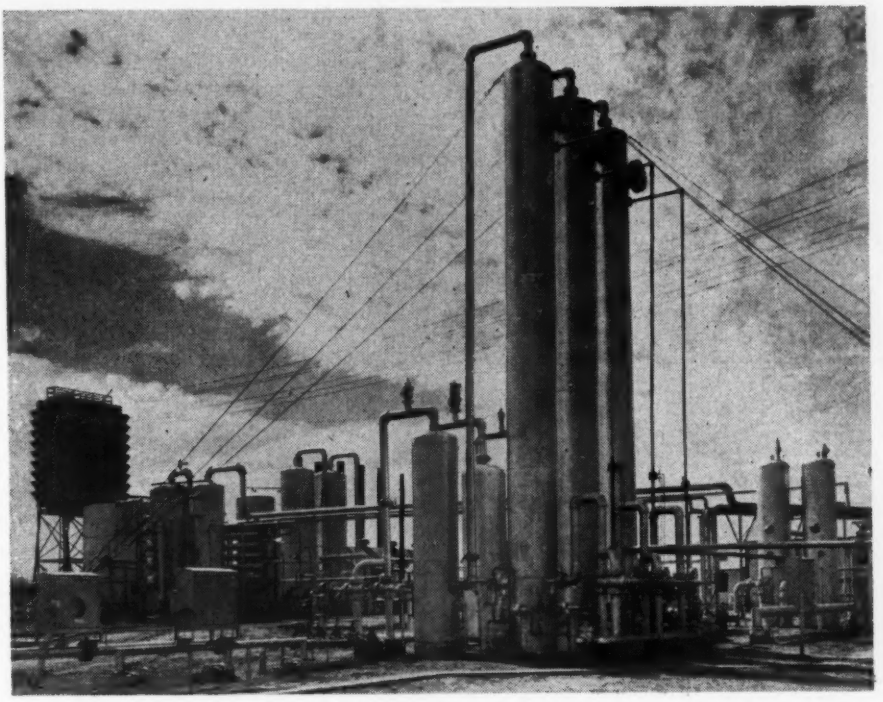
The vapor load on the original still probably will be doubled. If tests indicate the still has the desired capacity no radical changes will be involved, but it is unlikely that many plants will be so fortunate. However, it can be utilized by the installation of an additional still operating at 200 psi.

With two stills, the high-pressure still is operated only with sufficient steam to remove most of the hydrocarbons lighter than pentane, which also serves to keep steam demands out of the prohibitively high bracket. The heavy ends still remaining in the fat oil then are removed in the old 50 psi still, which thus will have no greater load than before. However, there must be no vapor loss off this secondary still accumulator, for any such will be valuable hydrocarbons.

A new accumulator pump is required to take suction off the secondary still accumulator at 50 psi, raising it to the 200 psi existing in the primary still accumulator.

Such a procedure eliminates a recompressor stage following what is now the secondary still, but permits full effect of absorptive capacity of the heavier hydrocarbons in recovering the maximum amount of C_3 and heavier. Pump for the de-ethanizer takes suction off the primary accumulator.

In a plant of the type assumed, it was originally equipped with a stabilizer and depropanizer. In all probability the original stabilizer will be adequate to handle the increased quantity of propane and butane produced, since formerly it handled not only incidental butane but the lighter hydrocarbons now being taken care of by the new de-ethanizer. Load on the other columns in the plant will not be changed.



(Photo courtesy F. M. Allen, Bodine plant supt.)

Absorber section of the recently-modernized Bodine plant, Cities Service Oil Co., near Oklahoma City. Tall columns are 250 psi absorbers with inlet and outlet gas scrubbers on either side. At extreme left is engine jacket-water cooler and storage, 50 psi still (two short columns) and two 50 psi reabsorbers

As in Case I, the de-ethanizer in Case II will operate at 250 psi. Vapors from its accumulator are plant fuel.

Case III Plants

Case III plants in general already operate the still and absorber at moderately high pressures, 200 psi or better, and have both depropanizer and de-ethanizer, certainly the former.

The first consideration would be an increase in oil rate, providing absorber, still and oil coolers will permit. If this is out of the question, refrigeration of the oil, wet gas or both will permit retention of the original rate or even reduce it. If the oil circulation already is high, oil refrigeration alone likely will be sufficient; if low, refrigeration of both oil and wet gas will be necessary.

The second consideration would be compression of the intake gas to 750 psi and the use of a high-pressure absorber, with the concluding operation similar to that used in the preceding Case II.

A third consideration would be the adoption of multi-stage flashing in connection with high-pressure absorption. In this method, raw gas is compressed to pipeline pressure with unchanged oil rate. Two or three stages of flashing likely will be sufficient, perhaps even one.

Fat oil at 750 psi from the absorbers is charged to a flash chamber through a controller which maintains pressure on the chamber of 400 psi, for example, if two stages are to be used. Oil then passes to a second chamber where pressure is further reduced to 200 psi, whence it is charged through the preheater into the original still. Depending on the actual amount of C_3s and heavier lost in the vent gases from the one or two flash chambers, this vent gas is used as plant fuel or passed through a reabsorber with a low oil rate and thence to disposal. (Oil from reabsorption is injected into the fat oil stream ahead of the still.)

Summary

Recapitulating with more detail on what has been said heretofore concerning costs; as there is, unfortunately, no one-shot way to increase propane recovery neither is there possible a clear-cut estimate of probable costs. In a very few cases substantial recoveries can be achieved at relatively nominal cost—a few thousand dollars. In *most* cases costs will be more appreciable. In some, costs will be quite substantial, 75 to 300% of original plant cost, without considering present-day labor and materials cost abnormalities. In a small number of cases costs will be entirely prohibitive.

For the cases previously enumerated, Case I particularly assumes that compressors are readily available and their installed cost less than for vessels. Case II assumes vessels are more easily procurable and cheaper to install than compressors. In practice a compromise may be necessary. Case III for the most part represents vessels, as compressors already are installed.

Assume the original Case I plant is the basic plant. That is, it made 26-lb. natural gasoline with a 50 psi still, its absorbers

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operated at not less than 100 psi and 30-40% of available butanes were extracted. Its cost was "$X000." Further assume that equipment today costs approximately the same as 10 years ago.

To convert a Case I plant to 95% butane recovery and incidental 25% propane recovery will cost in the neighborhood of 50 to 75% of the original plant cost.

To modernize a Case II plant, including redesign of absorption system, propane recovery of 25% to be doubled, and a considerable increase in compressor horsepower, will cost from 50 to 100% and probably toward the higher figure, of the original base price.

To convert the Case III plant to 80% propane recovery from its original 25%, tripling it, will require an investment ranging from 250 to 300% of the original plant cost.

These figures admittedly are conservative.

One additional consideration should be made in determining how much propane recovery is economically feasible from existing plants. Consider the plant which is selling its residue gas containing a gallon of propane per 1000 cu. ft. to a pipeline at 5c per Mcf. The propane it contains is worth 3c per gal., f.o.b. Houston area plant(5).

Propane at standard measurement conditions is the equivalent of 36 cu. ft. when expanded from liquid to gas; it has 2521 Btu per cu. ft., whereas pipeline gas, assumed to be largely methane, has 1011 Btu per cu. ft. If purchased strictly on a volume basis, as pipeline gas the gallon of propane will bring (36/1000) x 5c, or 0.180c per gal. If more properly figured on the basis of its relatively higher heat content, it will bring (2521/1011) (36/1000) x 5c, or 0.449c per gal. Sold as liquid propane it then is worth from 2.551 to 2.820c per gal. more than it is as pipeline gas.

Put another way, as pipeline gas some 28 gal. of propane are required for the plant to receive 5c, or on the heat content basis 12.50c. Twenty-eight gallons of liquid propane are worth 84c. This 84c minus 5c or 12.5c, representing 79c or 71.50c, respectively, must return as gross revenue within three years the capitalization involved in modernizing in order to amortize the alteration cost in the usual 5-year period.

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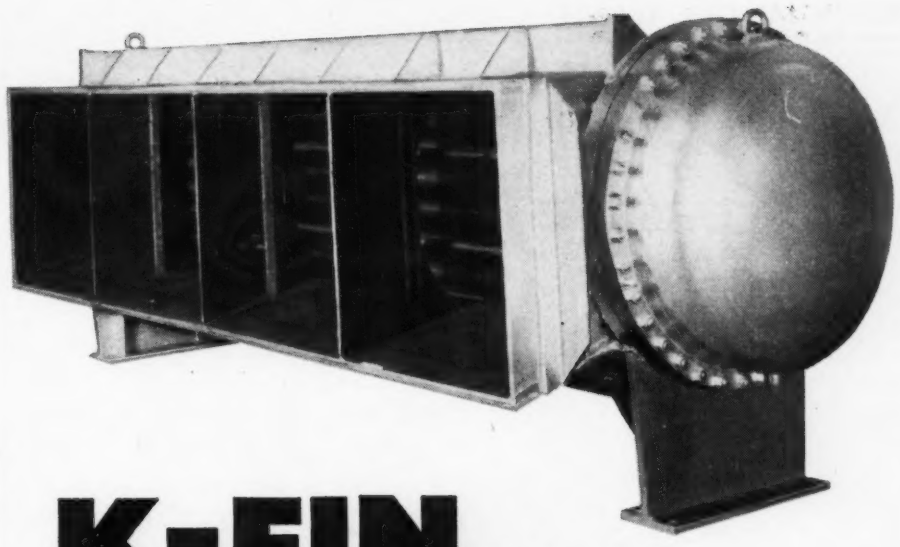

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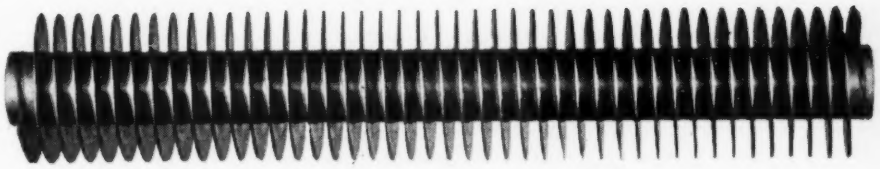

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Modern Metals Make the Steam Engine Feasible for Automobiles, SAE Told

By WILLIAM C. UHL
Equipment Editor
PETROLEUM PROCESSING

NEW automotive developments with potential effects for the petroleum industry as reported in technical papers presented at the Summer Meeting of the Society of Automotive Engineers at French Lick, June 1-6, include:*

1—Steam, or vapor, engines for motor trucks and buses with the advantage of one-half to one-third the present power plant size, with high efficiency operation, and using almost any low cost fuel. Application of modern design principles and the availability of high-strength cast irons and alloy steels make such engines feasible today.

2—Use of fuel injection to provide fuel economy in the operation of spark ignition engines. A figure was reported of between 35 and 45 miles per gallon, at 40 miles per hour for a 3400-pound vehicle.

3—The gas turbine, operating both a propeller and a jet mechanism in the so-called composite powered aircraft, is economically feasible. Its advantage is said to stem from use of high heat-releasing fuels available from petroleum hydrocarbons.

4—Development by an oil company of a method for continuous field and road testing of fuels and lubricants for control of sludge and other deposits in fleets of heavy-duty commercial trucks.

Brief reviews of some of the SAE papers reporting these developments are given below:

Steam Autos Again Possibility

"Thermodynamics of Vapor Power Plants for Motor Vehicles" by Edmund B. Neil, consulting engineer, Columbus, Ohio.

Steam engines for automotive vehicles appear to be a future possibility in view of research work just before and after the war in the design of power plants of the vapor type.

Present-day knowledge of materials and design principles can be applied to such power plants to fully realize their advantages for automotive equipment. The shortcomings of the early steam automobiles were largely due to the lack of today's commonly-used materials such as high-strength cast irons and alloy steels, the paper brings out.

Steam, or vapor, engines can be developed for economic use in trucks and busses with one-half to one-third present power plant sizes and high engine efficiency. Further advantages were described as simplification of fuel carburetion and ignition, silent operation, elimination of clutch and transmission, and smooth constant acceleration.

Because of the similarity to Diesel cycle, the author suggested the application of steam engines most particularly to Diesel uses, such as heavy-duty, long distance service.

The engine could use any low-cost liquid fuel and therefore would offset the higher fuel consumption which might be incurred in some classes of service.

The author cited considerable technical and operating data from early models in commercial use, and indicated how modern development could overcome the shortcomings. Among the causes of failure, he mentioned:

1. Strong promotion of gasoline cars. Steam was considered "old-fashioned," "gas" cars were new and modern. Misrepresentation of steam car hazards.

2. Long cold starting time of earlier vehicles. This was largely overcome in later designs.

3. Complexity of controls, some of which were rather delicate. Dependency was placed upon the car owner for too much knowledge necessary to obtain proper operation. There was little, if any, development of servicing facilities for the early steam cars.

4. Initial cost of vehicle was high because of small production and insistence by manufacturers of continuing old and established designs.

Fuel Injection Improves Economy

"Fuel Injection Engine with Spark Ignition," by Allan M. Starr, consulting engineer, Starr & Sweetland, Piedmont, Calif.

Improved part-load fuel economy is said to be the chief advantage of a modified Diesel engine using fuel injection and with spark ignition supplanting the usual compression ignition.

Operating at a compression ratio of between 7 and 10 to 1, the engine's fuel economy is demonstrated by the fuel mileage curve shown in Fig. 1, under level road conditions with a car weighing 3400 lbs. equipped with a 200 cu. in. displacement engine. The test is the result of running the car both directions and averaging the results. Fuel economy is between 35 and 45 mpg at 40 mph.

Greatest difficulty in developing the

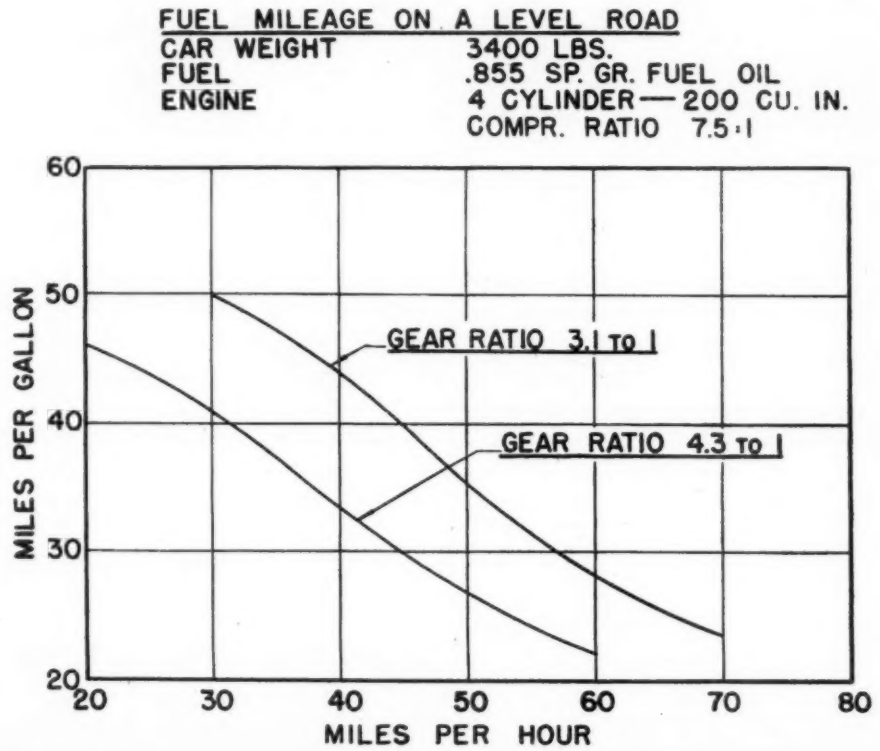

Fig. 1—Fuel mileage curves at two gear ratios for the modified Diesel-type engine which uses fuel injection and spark ignition

* For review of the paper and discussion on the General Motors experimental 12.5 to 1 compression ratio automobile engine, at the SAE French Lick meeting, see PETROLEUM PROCESSING, July, 1947, pgs. 485-489.

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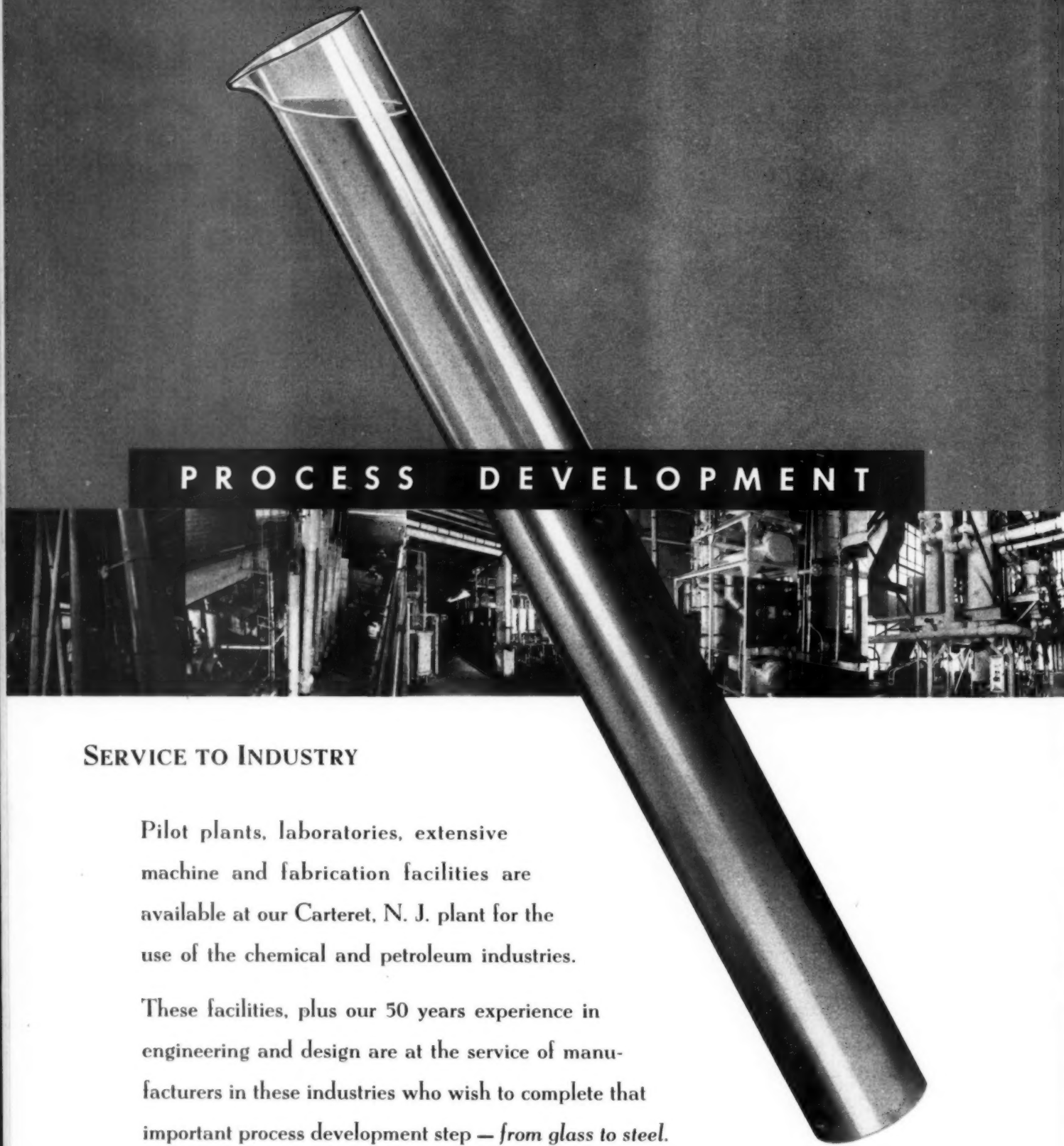

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engine was to obtain reliable ignition throughout all loads and speeds.

"The engine operates with the air intake wide open at all loads," the paper stated, "and the consequent combustion is such that the part-load fuel economy resembles that of the Diesel."

Intake and exhaust valve heads are flush with the cylinder head and close to the piston. Adjacent is a cone-shaped combustion chamber, comprising the compression space, into which a nozzle injects fuel. The fuel mixes with a residual charge and the combination is fired by a spark.

When the engine operates at light loads the injected fuel does not penetrate the entire contents of the combustion chamber, but only about as far as the spark points in the upper hot region. Hence an ignitible air-fuel mixture is available at light loads. As the load increases, more and more air is penetrated by the injected fuel by the time the ignition spark occurs.

"When operating at about a quarter load or less it has been found very difficult, if not impossible, to ignite and burn all the fuel charge before it gets lost in too much excess air," the paper points out. "Also, at very light loads the spark plugs run too cool to stay clean.

"For these reasons it has been found very helpful to cut out half the engine's cylinders when operating at low loads, a quarter or less. Then the cylinders that remain in operation carry sufficient load to insure clean efficient combustion.

A mechanical arrangement is used to provide this cutout of half the cylinders at 25% load. Linked to the governor or throttle control the fuel metering pump can be made to give smooth and stable performance throughout the load and speed range of the engine.

Test engines were built satisfactorily from standard production cylinder blocks, pistons, and bearings used in normal gasoline engines, it was stated. They have been run in an automobile and some tractors for several years with satisfactory results, using 6-volt starters or hand cranks.

Various Diesel fuels have been tested in the engine with approximately equivalent results. Knock rating, ignition rating, and volatility do not seem to make much difference in performance. "If the engine were more highly developed, it would probably do best with fuels having a moderate octane rating."

Favors Composite Power Plants

"An Analysis of Composite-Powered Aircraft," by Ben T. Salmon, formerly chief engineer, Ryan Aeronautical Co.

Power plants combining turbines with propellers and jets are recommended as ideal for aircraft.

The composite-powered airplane, of which the U. S. Navy's FR-1 "Fireball" is a prototype, is said to offer such advantages as reduced engine weight and fuel requirements, highly important in aircraft where the power plant and the useful load constitute about 60% of the total weight.

Pointing out that it should be possible to find in crude oil new fuels which will give even greater power with less consumption in turbo-prop and turbo-jet engines, it was estimated that even now the gas turbine will produce four times the power at half the cost of a reciprocating engine.

"For example, it has been determined that the cost per pound of the General-Electric-designed I-40 gas turbine is running about one-half that of a good liquid-cooled reciprocating engine such as the Allison V-1710," the paper said.

"If a V-1710 costs about $30,000 and weighs 2000 lbs., it will cost about $15/lb. By contrast, the I-40, which develops four times the power at 500 mph, will cost around $7.50/lb. Further reductions in cost will be effected as volume production is attained with the I-40, because these cost comparisons were based on a production of 1200 of the I-40's and 80,000 of the V-1710's."

Develops Practical Road Tests

"Field Testing of Motor Oil and Gasoline," by A. C. Pilger, Jr., in charge of Automotive Field Research, Tide Water Associated Oil Co., Eastern Division.

A test technique developed by Tide Water Associated Oil Co. Inc., for controlled road tests in overload, highway truck service permits evaluation of fuel, lubricant, engine design, and operating factors in terms of the varnish, sludge, and bearing corrosion.

Test method is reported to be practical and low in cost. It has been in use over an 8-year period, since 1939. "The procedure closely parallels the technique used in conducting laboratory engine tests," the paper stated. "It adapts itself to the development of more significant laboratory test interpretations and procedures, and in certain instances may be used to replace the laboratory work."

It is a permanent program with its own personnel and location. The tests, instead of being statistical, are specific in nature and require close control. Once test reproducibility and sensitivity are established, the study of a variety of products and factors is undertaken. Throughout the work a base or reference oil is run at frequent intervals to check for uncontrolled variables and any wandering in the severity of service. All test vehicles are the property of a fleet operator and are run by his personnel in normal revenue service.

About five commercial truck fleet operators in the Detroit area have cooperated in the project. Still in progress, the program in May, 1947, had totalled 1,315,000 miles of operation representing 180 specific tests. Five different engine designs were included. The first five years, until 1944, were devoted wholly to lubricating oils; since that time gasoline has been added as a test variable.

TABLE 1—Commercial Operating Conditions

Fuel Consumption, mpg.	5 to 6
Oil Sump Temperature, F.	200-220*
Water Temperature—head, F.	145-165*
Water Temperature—jacket, F. (#6 cyl.)	165-185*
Load, semi-trailer, max. allowable payload 22,000 lbs. Tractor size, capacity, tons	1½ or 2
Engine, no. of cylinders	6

* Range of averages based on readings after engine warm-up.

Operating conditions are shown in Table 1. The fleets operate tractor-trailer units between Detroit and Saginaw. Vehicles make a round trip each night, six nights a week. During the day, the tractors are used part time for city freight pick-up. The vehicles operate full throttle when traffic permits, a large portion of the time on the night runs, once they leave Detroit. Normal running time for the one-way 96 mile trip is about three hours.

The effect of fuels and lubes on engine cleanliness was rated under seven points—six specific locations and an overall rating. Included were piston skirt varnish, piston ring blocking, valve stem lacquering, push rod cover plate, overhead rocker assembly sludge, and oil screen blocking.

For the required, engine tear-down and inspection at regular intervals the fleet operators' shops were used in the early stages of the program. Later this was discontinued and the work carried out in five factory branches in Detroit and one in Pontiac.

The use of an outside shop, preferably a factory branch corresponding to the make of vehicle used, was found to be the more desirable means of handling mechanical work. It enabled tear-downs to be scheduled at the proper time and completed without interruption. A regular mechanic could be trained and assigned to the work. Also a good stock of standard parts was more readily available.

Control of field operations was maintained at all times by a group of field test engineers from Tide Water. Truck drivers were relieved of all responsibility for fueling, oiling, or maintaining the engine in each test vehicle. The oil company's field staff was on 24-hr. call in case of any emergency breakdowns. Full cooperation and backing by the fleet operator is of course essential to a successful program.

Most of the results reported in the paper were based on a test run of 6000 miles, approximately one month, one oil drain, no oil filter, sampling used oil each 2000 miles, and with a maximum allowable oil consumption of 400 miles/quart.

MODERN MANUFACTURE O

Many improvements in methods for the solvent extraction of lubricating oils, treatment of finished products and preparation of feed stocks are incorporated in new plants currently being installed.

Propane deasphalting is used in conjunction with vacuum distillation in the preparation of feed stocks. New solvent extraction construction indicates a trend for the single solvents furfural and phenol, and a preference for the benzol-ketone solvent dewaxing process for the manufacture of both crystalline and micro-crystalline waxes. Continuous clay contacting and clay percolation are used for finishing the solvent extracted oils. New machines are on the market for continuously and accurately blending lubricating oils and additives.

A discussion of the economics involved indicates modern lubricating oil plants will be profitable, even under conditions more unfavorable than are today's.

THE petroleum refining industry was very active during the war years with the installation of refining facilities for the production of aviation gasoline, synthetic rubber and toluene, which program included some additional crude topping facilities. In the lubricating oil field, however, practically no new facilities were installed since it was possible to meet the wartime demands for lube oils with existing facilities.

The increased production requirements as well as the developments influencing quality demands are responsible at present for a large program of construction of new modern lubricating oil plant facilities. The developments in the industry which have influenced the quality requirements of lubricating oils have been the increased use of higher compression ratio engines, higher speed machinery and diesel engines.

Present production of lubricating oils in the U. S. is in the order of 120,000 b/d. Present construction of solvent deasphalting, refining and dewaxing plants for the production of high quality lubricating oils would result in approximately 40,000 b/d finished production, of which it is estimated that roughly two-thirds will be for replacement of obsolete process methods and one-third for new increased production.

Modern lubricating oil facilities are now being installed by 15 refiners in the U. S. and in 5 locations outside this country. These facilities on the whole include the use of vacuum distillation and, in many cases, propane deasphalting for the preparation of the raw lube oil stocks. Single solvent refining follows with the use of either furfural or phenol as a single solvent, and in most cases the plants are designed for the production of 95 Viscosity Index oils at zero pour.

The solvent refined oils are then processed through a solvent dewaxing plant for obtaining the pour point requirement. Many of these plants are installing equipment in the solvent dewaxing unit for the production of low oil content waxes either continuously or by blocked operation. The final finishing of the oils is handled by either clay contacting or percolation.

Table 1 shows a list of the propane deasphalting plants in operation and under construction. It will be noted that as many propane deasphalting plants are at present under construction as were built prior to the war, indicating the increased interest shown by lube oil manufacturers in the use of this process.

Tables 1, 2 and 3, listing modern lubricant manufacturing plants now built and building, appear on page 597.

Table 2 lists the solvent extraction plants subdivided in accordance with the solvent used. This table indicates that the selection of solvent refining plants by refiners at present has been largely reduced to the use of either furfural or phenol. This table also shows that the increase in solvent refining plants since the war was concluded has been in the order of 40% over those existing and built during the period from 1932 until the outbreak of the war.

Table 3 gives a list of the solvent dewaxing plants. This table indicates the popularity of the benzol-ketone dewaxing process and also shows that the installation of new postwar dewaxing facilities represents over 50% of the number of plants built prior to the war.

Fig. 1 shows a complete lube oil processing system which most refiners are using in the construction of their new facilities.

Vacuum Distillation

Virtually all raw lubricating oil stocks are now prepared by the vacuum distillation of reduced crude. Developments in vacuum distillation have been directed towards the production of more accurately separated raw distillate cuts with a minimum of degradation. Absolute pressures of as low as 30 mm Hg at the tower flash zone are being achieved by the use of specially designed decks and efficient vacuum jet equipment. Two or three lube distillates are generally made simultaneously as side streams while gas oil is taken overhead and a short residue is withdrawn from the bottom of the tower. This short residue may be used for the production of specification asphalt or fuel oil, or it may be charged to a propane deasphalting unit for the production of bright stock.

The practice of producing several fairly narrow distillate cuts and processing them seperately through subsequent steps is generally accepted as a desirable route. Each fraction can be solvent treated and finished under optimum conditions. The finished fractions are then used as base stocks for blending to final lubes. This affords the refiner a maximum flexibility in his lube blending schedules permitting optimum production and quality for varying demand pictures.

An alternate method used occasionally by some refiners is the production from primary distillation of a wide range residue. This cut after solvent refining and dewaxing is rerun under vacuum to produce the desired blending

OF LUBRICATING OILS

By E. R. SMOLEY
and D. FULTON
The Lummus Co.

stocks. This rerun operation is sometimes combined with clay contacting in the process called filtrol fractionation.

Propane Deasphalting

An outstanding feature of modern lube oil refining is the increased use of propane deasphalting for the production of bright stock. This process is capable of extracting all of the heavy lube oil from most reduced crudes. This process shows considerable flexibility in the manufacture of lube oils from varying percentages of reduced crude as well as varying asphalt contents. It permits the production of clean bright stocks with considerable variation in finished viscosities from varying reduced crudes. For example, starting with a crude of the Mid-Continent type, if a 20% bottoms is charged to a propane deasphalting unit and subsequently solvent refined and dewaxed to 95 V. I., zero pour, the resulting bright stock would have a viscosity of about 130-150 SSU at 210°F.

If a bottoms of 11% on crude is processed in the same manner, the finished stock viscosity would be in the neighborhood of 200-250 SSU at 210°F. These figures are based on recovering the maximum amount of usable lube oil in the residue, while still retaining a reasonable carbon residue specification on the finished oil. The process may be operated so as to produce specialty products, using more drastic treating conditions at a sacrifice of yield and viscosity.

The propane deasphalting process was originally developed using tank-type stage settlers; the more recent plants, however, have incorporated a countercurrent treating tower similar to those used in the solvent refining processes. The use of such a tower results in increased yields and product quality, since it provides many more theoretical contacting stages than are economically possible in the stage arrangements. Fig. 2 illustrates a typical propane deasphalting unit process flow.

An important decision every refiner must make when contemplating the installation of a lubricating oil plant is exactly how deep in the crude the raw lube stocks should be produced as vacuum distillates, and where propane deasphalting should begin. In other words,

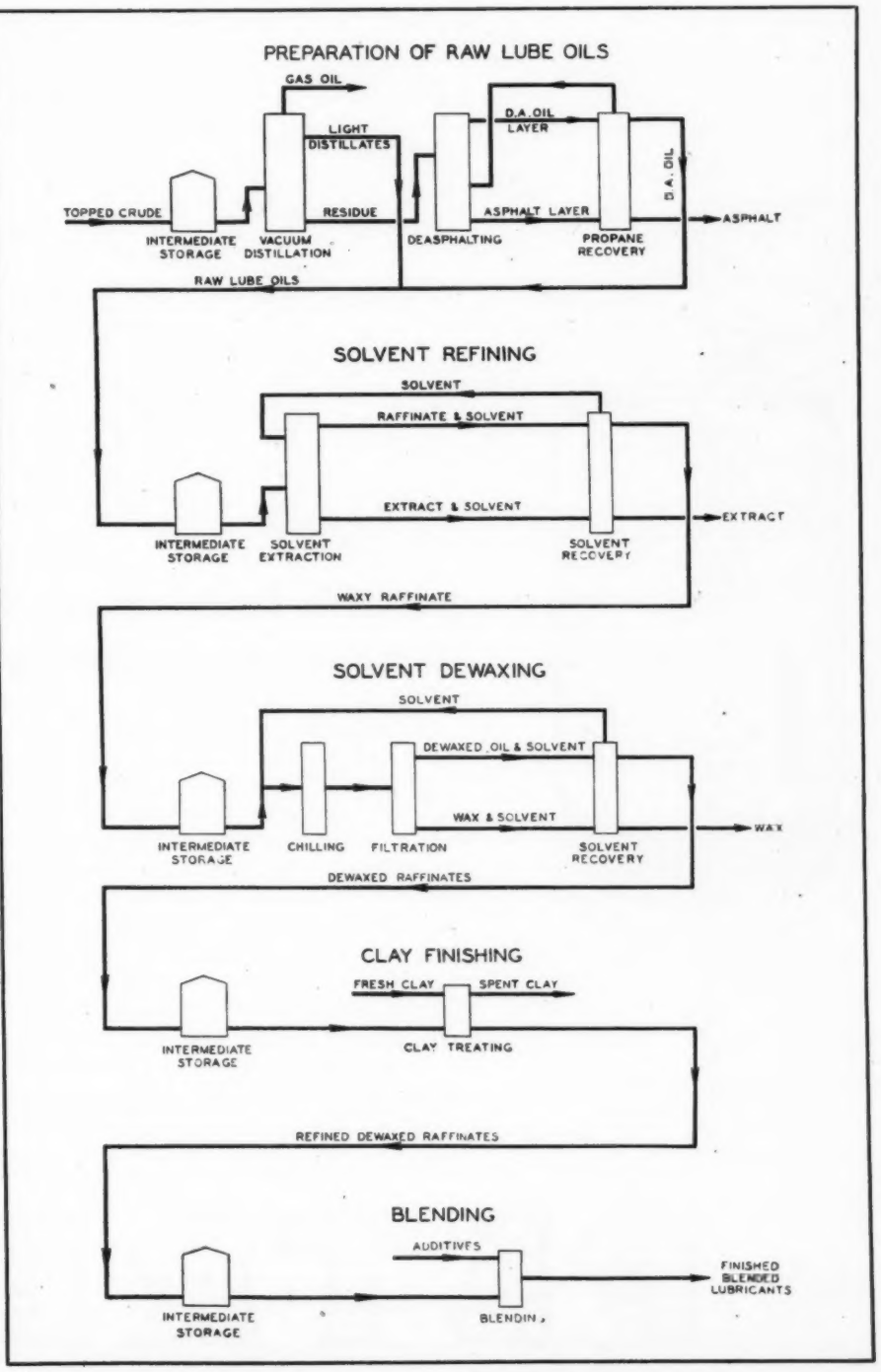
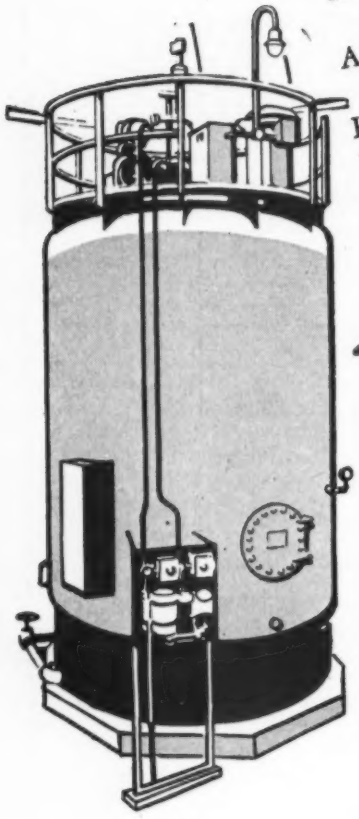


Fig. 1—Complete modern lube oil processing system

CAN YOU CHECK *Yes*

TO THESE 8 QUESTIONS?...

Can you charge any crude stock?	YES ☐	NO ☐
Are you getting maximum continuous crude throughput?	YES ☐	NO ☐
Is your heat exchange efficient?	YES ☐	NO ☐
Have you reduced HCl corrosion to a minimum?	YES ☐	NO ☐
Are maintenance costs low?	YES ☐	NO ☐
Have you eliminated or reduced tank bottoms to a minimum?	YES ☐	NO ☐
Are you getting maximum continuous time on stream?	YES ☐	NO ☐
Can you operate on a time schedule?	YES ☐	NO ☐



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PB 47-D

TABLES 1, 2, 3—Modern Lubricant Manufacturing Plants Built and Building

TABLE 1—Propane Deasphalting Plants

Refinery	Location and Chg. Cap., b/d	
1. Union Oil Co. of Calif.	Oleum, Calif.	2,000
2. Shell Petroleum Co.	Wood River, Ill.	3,300
3. The Texas Co.	Port Arthur, Texas	1,960
4. Standard Oil Co. (Indiana)	Whiting, Indiana	1,200
5. Kendall Refining Co.	Bradford, Pa.	900
6. Humble Oil & Refining Co.	Baytown, Texas	4,800
7. Bradford Penn. Refining Co.	Warren, Pa.	250
8. Standard Oil Co. of Louisiana	Baton Rouge, La.	2,100
9. Sinclair Refining Co.	Houston, Texas	3,500
10. *Atlantic Refining Co.	Philadelphia, Pa.	....
11. *The Pure Oil Co.	Smiths Bluff, Texas	....
12. *Sinclair Refining Co.	E. Chicago, Indiana	....
13. *Shell Oil Co.	Houston, Texas	....
14. *Phillips Petroleum Co.	Kansas City, Mo.	....
15. *Tide Water Associated Oil Co.	Bayonne, N. J.	....
16. *Sun Oil Co.	Marcus Hook, Pa.	....
17. *Standard Oil Co. (Indiana)	Whiting, Indiana	....

TABLE 2—Solvent Extraction Plants

Furfural Process

1. Gulf Oil Corp.	Port Arthur, Texas	5,000
2. Indian Refining Co.	Lawrenceville, Ill.	2,400
3. The Texas Co.	Port Arthur, Texas	10,000
4. Magnolia Petroleum Co.	Beaumont, Texas	3,200
5. Shell Oil Co.	Martinez, Calif.	3,250
6. Quaker State Refining Co.	McKean, Pa.	1,700
7. Quaker State Refining Co.	St. Mary's, W. Va.	600
8. Quaker State Refining Co.	Emlenton, Pa.	1,700
9. Continental Oil Co.	Ponca City, Okla.	1,500
10. Golden Bear Oil Co.	Bakersfield, Calif.	500
11. British American Oil Co. Ltd.	Clarkson, Ont., Canada	1,750
12. Shell Refineries, Ltd.	Shell Haven, England	1,650
13. Trinidad Leaseholds, Ltd.	Point-a-Pierre, Trinidad	2,910
14. *Cooperative Refinery Assoc.	Coffeyville, Kansas	....
15. *Socony-Vacuum Oil Co. Inc.	Paulsboro, N. J.	....
16. *Magnolia Petroleum Co.	Beaumont, Texas	....
17. *Tide Water Assoc. Oil Co.	Bayonne, N. J.	....
18. *Sun Oil Co.	Marcus Hook, Pa.	....
19. *Consolidated Refineries Ltd.	Haifa, Palestine	....
20. *Anglo-Iranian Oil Company	Abadan, Iran	....

Phenol Process

1. Kendall Refining Co.	Bradford, Pa.	1,400
2. Imperial Oil Co.	Sarnia, Canada	2,500
3. Standard Oil Co. of New Jersey	Bayonne, N. J.	1,750
4. Standard Oil Co. of Louisiana	Baton Rouge, La.	5,000
5. Standard Oil Co. of Calif.	Richmond, Calif.	3,500
6. International Petroleum Co.	Colombia	300
7. Standard Oil Co. of Louisiana	Baton Rouge, La.	1,900
8. Humble Oil & Refining Co.	Baytown, Texas	8,000
9. Union Oil Co. of Calif.	Oleum, Calif.	2,000
10. Sinclair Refining Co.	Houston, Texas	4,000
11. Gulf Oil Corp.	Port Arthur, Texas	3,100
12. *Sinclair Refining Co.	East Chicago, Ind.	....
13. *Shell Oil Co.	Houston, Texas	....
14. *Atlantic Refining Co.	Philadelphia, Pa.	....
15. *Phillips Petroleum Co.	Kansas City, Mo.	....
16. *Standard Oil Co. (Indiana)	Whiting, Ind.	....
17. *The Pure Oil Co.	Smiths Bluff, Texas	....
18. *Creole Petroleum Co.	Venezuela	....

Duosol Process

1. Socony-Vacuum Oil Co.	Paulsboro, N. J.	6,000
2. Magnolia Petroleum Co.	Beaumont, Texas	2,800
3. Gulf Oil Corp.	Girard Point, Pa.	2,500
4. Shell Refining Co.	Stanlow, England	2,000
5. Shell Petroleum Corp.	Wood River, Ill.	3,000
6. Standard Oil Co. of Calif.	Richmond, Calif.	3,500
7. Continental Oil Co.	Ponca City, Okla.	1,800
8. Standard Oil Co. of Calif.	El Segundo, Calif.	5,000
9. Sun Oil Company	Marcus Hook, Pa.	5,000
10. Champlin Refining Co.	Enid, Okla.	1,200

* Under Construction.

TABLE 2 (Continued)

SO_2-Benzol Process

Refinery	Location and Chg. Cap., b/d	
1. Tide Water Assoc. Oil Co.	Avon, Calif.	1,500
2. Shell Oil Co. of Calif.	Richmond, Calif.	1,500
3. Union Oil Co. of Calif.	Oleum, Calif.	1,500
4. Lobitos Oil Fields, Ltd.	Ellesmereport, England	500
5. Anglo-Iranian Oil Co.	Llandarcy, Wales	1,600
6. The Texas Co.	Port Arthur, Texas	1,000
7. Tide Water Assoc. Oil Co.	Bayonne, N. J.	2,000
8. Manchester Oil Refinery	Manchester, England	700

Chlorex Process

1. Standard Oil Co. (Indiana)	Wood River, Ill.	1,000
2. The Pennzoil Co.	Rouseville, Pa.	1,000
3. Mid-Continent Petroleum Co.	Tulsa, Okla.	900
4. Socony-Vacuum Oil Co. Inc.	Olean, N. Y.	1,700
5. Standard Oil Co. (Indiana)	Casper, Wyoming	600
6. Bradford Penn. Refining Co.	Clarendon, Pa.	500

Nitrobenzene Process

1. Atlantic Refining Co.	Philadelphia, Pa.	2,350
2. **Sinclair Refining Co.	Wellsville, N. Y.	800

** Nitrobenzene—Sulfuric acid.

TABLE 3—Solvent Dewaxing Plants

MEK—Benzol Process

1. Indian Refining Co.	Lawrenceville, Ill.	1,400
2. Atlantic Refining Co.	Philadelphia, Pa.	600
3. Gulf Oil Corp.	Port Arthur, Texas	1,500
4. Socony-Vacuum Oil Co. Inc.	Paulsboro, N. J.	3,800
5. The Texas Co.	Port Arthur, Texas	5,000
6. Socony-Vacuum Oil Co. Inc.	Olean, N. Y.	2,850
7. Quaker State Refining Co.	McKean, Pa.	1,800
8. Magnolia Petroleum Co.	Beaumont, Texas	3,400
9. Bradford Oil Refining Co.	Bradford, Pa.	800
10. Tide Water Assoc. Oil Co.	Bayonne, N. J.	1,200
11. Standard Oil Co. of Calif.	Richmond, Calif.	2,200
12. Sinclair Refining Co.	Wellsville, N. Y.	4,500
13. Continental Oil Co.	Ponca City, Okla.	1,100
14. Sinclair Refining Co.	Houston, Texas	3,500
15. Quaker State Refining Co.	Emlenton, Pa.	1,200
16. British American Oil Co. Ltd.	Clarkson, Ont., Can.	1,400
17. Sun Oil Co.	Marcus Hook, Pa.	3,500
18. Gulf Oil Corp.	Port Arthur, Texas	2,200
19. Petrolite Corp.	Kilgore, Texas	100
20. Shell Refineries, Ltd.	Shell Haven, England	1,500
21. Attock Oil Co. Ltd.	Rawalpindi, India	450
22. Shell Refineries, Ltd.	Stanlow, England	1,300
23. *Atlantic Refining Co.	Philadelphia, Pa.	....
24. *Humble Oil & Refining Co.	Baytown, Texas	....
25. *Sinclair Refining Co.	East Chicago, Ind.	....
26. *Shell Oil Co.	Houston, Texas	....
27. *The Pure Oil Co.	Smiths Bluff, Texas	....
28. *Socony-Vacuum Oil Co.	Paulsboro, N. J.	....
29. *Magnolia Petroleum Co.	Beaumont, Texas	....
30. *Standard Oil Co. of Louisiana	Baton Rouge, La.	....
31. *Sun Oil Co.	Marcus Hook, Pa.	....
32. *Tide Water Assoc. Oil Co.	Bayonne, N. J.	....
33. *Consolidated Refineries Ltd.	Haifa, Palestine	....
34. *Anglo-Iranian Oil Co.	Abadan, Iran	....

Propane Dewaxing Process

1. Standard Oil Co. (Indiana)	Wood River, Ill.	1,300
2. Union Oil Co. of Calif.	Oleum, Calif.	1,300
3. Shell Petroleum Co.	Wood River, Ill.	3,600
4. Kendall Refining Co.	Bradford, Pa.	1,200
5. Humble Oil & Refining Co.	Baytown, Texas	3,700
6. Standard Oil Co. of Louisiana	Baton Rouge, La.	2,200
7. *Phillips Petroleum Co.	Kansas City, Mo.	....
8. *Standard Oil Co. (Indiana)	Whiting, Indiana	....
9. *Creole Petroleum Corp.	Venezuela	....

SO_2-Benzol Dewaxing Process

1. Anglo-Iranian Oil Co.	Llandarcy, Wales	1,600
2. Lobitos Oil Fields Ltd.	Ellesmereport, England	350
3. Manchester Oil Refinery	Manchester, England	450

Barisol Process

1. Standard Oil Co. of Louisiana	Baton Rouge, La.	1,800
2. Continental Oil Co.	Ponca City, Okla.	400
3. Standard Oil Co. of Calif.		2,500

Single solvent lube refining plant. Three tanks in foreground are for solvent storage. Large tower immediately behind them is the counter current extraction tower. In background are solvent recovery towers

where should the split be made between distillation and deasphalting for producing heavier lube fractions? There is a practical limit to the viscosity of distillates which can be made in a conventional vacuum unit. It is believed that this limit for finished lube is in the range of 110-120 SSU at 210° F. and represents a very narrow cut bottom side stream.

On the other hand, as noted before, the propane process can be used to produce finished oils of a wide range of viscosities up to 250 SSU at 210° F. or even higher. Consideration must be given to the effect of desired viscosity of bright stock production on the size of the propane deasphalting unit. The higher the bright stock viscosity the smaller the plant required. It is generally thought that the most economical picture is obtained by producing vacuum distillates to the maximum practical viscosity and producing the bright stock needed by propane deasphalting to balance the blending picture.

By "maximum practical viscosity" is meant the distillate viscosities which can be obtained practically without using specially designed uneconomic equipment to reach extremely high vacuums, or without resorting to excessive amounts of process steam to lower the oil partial pressure. The flash temperature is limited in all cases by the necessity of avoiding cracking and resultant degradation of the lube distillates.

The above considerations usually result in a process scheme for Mid-Continent type crude producing two or three distillates, the heaviest of which finishes to a viscosity corresponding to about SAE 40 to 50, and a propane deasphalted oil finishing as a bright stock of about 160 SSU at 210° F.

In the average self-contained motor lube blending schedule, when processing a complete reduced crude, there is frequently an excess of bright stock production. The propane deasphalting unit for balanced blending schedule would then be smaller than if it were designed to handle the entire amount of residue. However, the sales picture at present shows greater profitability when producing excess bright stock for sale, or finishing the excess heavy stock for cylinder stock sales. It is usually necessary to make a detailed study of markets and trends and general economic conditions in order to determine the size of a propane deasphalting unit.

The current trend is definitely toward the use of propane deasphalting to some extent in each lubricating oil refinery so that it produces its own supply of bright stock and is independent of outside sources.

Solvent Refining

In order to maintain a competitive position in the first grade motor oil field, every refiner must be able to market oils with a Viscosity Index of 95 or higher and stability characteristics which are obtained economically only by the use of solvent refining. A wide variety of these solvents have been used, including furfural, phenol, propane-cresylic acid, SO_2-benzol, chlorex and nitrobenzene. Table 2 indicates the location of these plants.

SO_2-benzol, chlorex and nitrobenzene are used in a number of the plants built prior to the war. Propane-cresylic acid, known under the name of "Duosol process", is also used in a number of plants and combines propane deasphalting and solvent refining in the same process. The process handles either short or long residues and when processing the latter the raffinate is vacuum rerun into the various blending stocks.

Since the war the refining industry has selected propane deasphalting plus a single solvent in the majority of cases. This selection has been due primarily to the economics involved as well as the greater flexibility obtained with separate processes. Table 2 indicates this trend of the preference in new construction for the single solvents furfural and phenol.

The general flow scheme and type of equipment used for these two processes are quite similar. The yields and product quality from the two processes are very similar, and plant investment and operating costs are likewise very much the same. Most of the new developments in solvent refining center around improving the efficiency of the counter-current extraction tower which has been improved in both cases in the light of plant experience. Figs. 3 and 4 give process flow diagrams for fufural and phenol refining units.

Solvent Dewaxing

The two principal types of solvent dewaxing at present are the benzol-ketone and the propane dewaxing processes. Table 3 lists the locations of these plants and indicates the wide acceptance of the benzol-ketone process for new installations. Fig. 5 shows the process flow of a benzol-ketone dewaxing unit.

The benzol-ketone process provides an extremely useful tool not only for the production of low pour test lubricating oil but also for the manufacture of both crystalline and micro-crystalline wax. During the last few years several major developments have taken place in the adaptation of this process to wax production. The process was first applied to wax manufacture by resorting to "blocked operation", where slack wax

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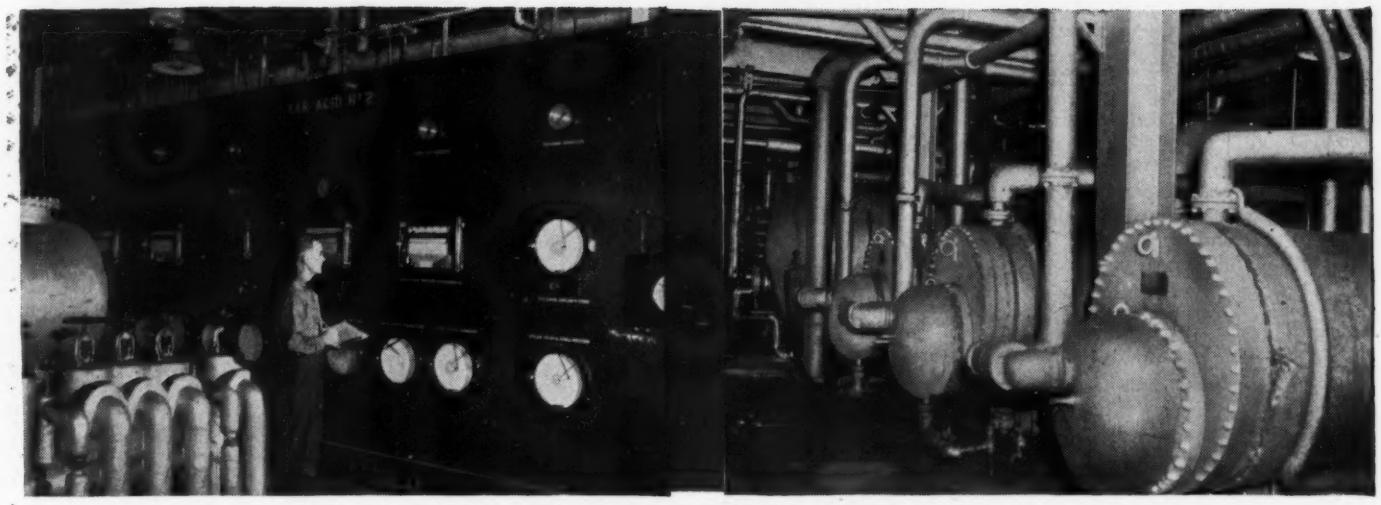

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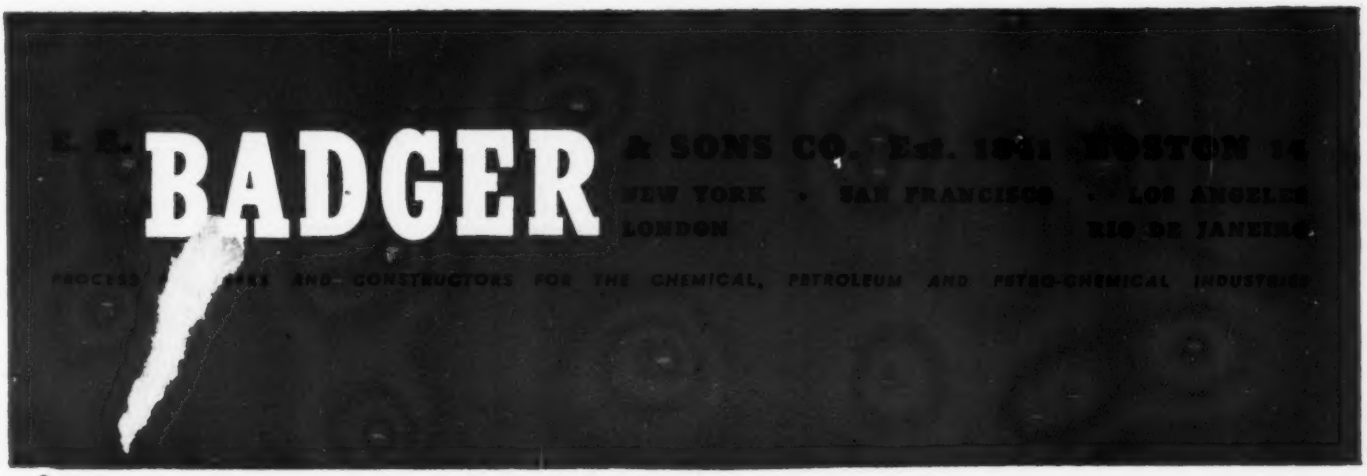
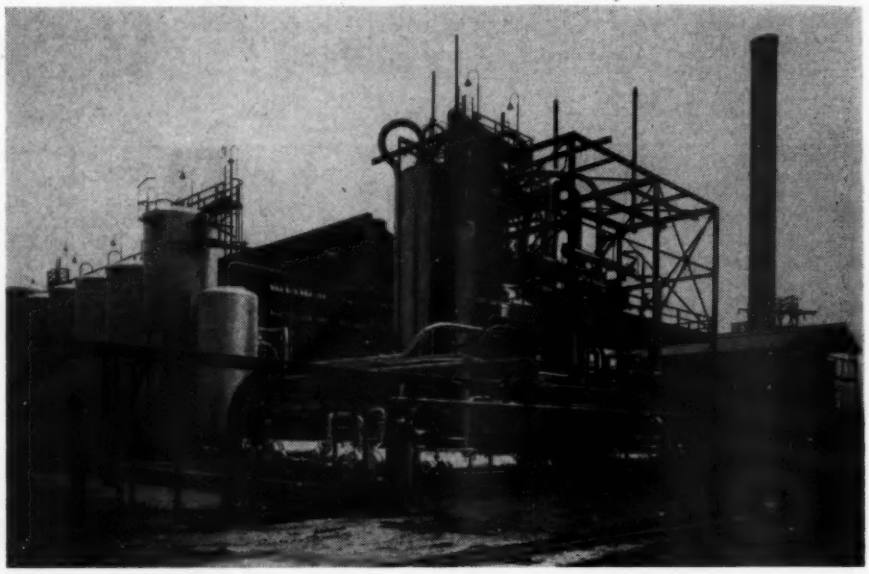


from dewaxing runs was stored and reprocessed through the dewaxing unit in order to reduce the oil content and to meet melting point requirements. It was found possible to make wax containing less than one per cent of oil by this method, usually by running the wax through the plant twice.

Later, the use of continuous deoiling of the wax by "normal sequence" was carried out. The slack wax from the zero pour dewaxing step was continuously repulped or recrystallized with added solvent and heating and cooling and passed over another filter for the production of low oil content wax.

A more recent development is the so-called "reverse sequence" process whereby zero pour oil and low oil content wax are produced simultaneously in the following manner: The charge oil, mixed with solvent, is chilled to an intermediate temperature and the high melting point wax removed by filtration. The filtrate from this step is then chilled to subzero temperatures for the removal of the low melting point waxes, the filtrate from this step containing the low pour test oil. The wax removed in the second step becomes a by-product usually sent to cracking.

Economy is obtained in this process by the use of incremental solvent injection. This involves the introduction of dilution solvent in small stages through the chilling train so that crystallization is carefully controlled using a minimum of solvent. The overall solvent requirement for this type of operation is understood to be no more than that required for simple dewaxing.



Large MEK dewaxing plant. Tanks at left are primarily for solvent storage. Large building in center is filter building. Equipment in foreground is solvent recovery section. At right are direct-fired heaters for solvent recovery section

Wax Manufacture

The war stimulated the production of both crystalline and microcrystalline waxes because of the many new uses. These demands have continued in the post-war period and many further new uses are being found. In the early days before solvent dewaxing processes, crystalline waxes were produced by the press method followed by sweating. With solvent dewaxing available, crystalline waxes were made in many cases by sweating the slack wax produced in the solvent dewaxing operation. In many cases, particularly where no sweating equipment was available, these crystalline waxes were made entirely by reproc-

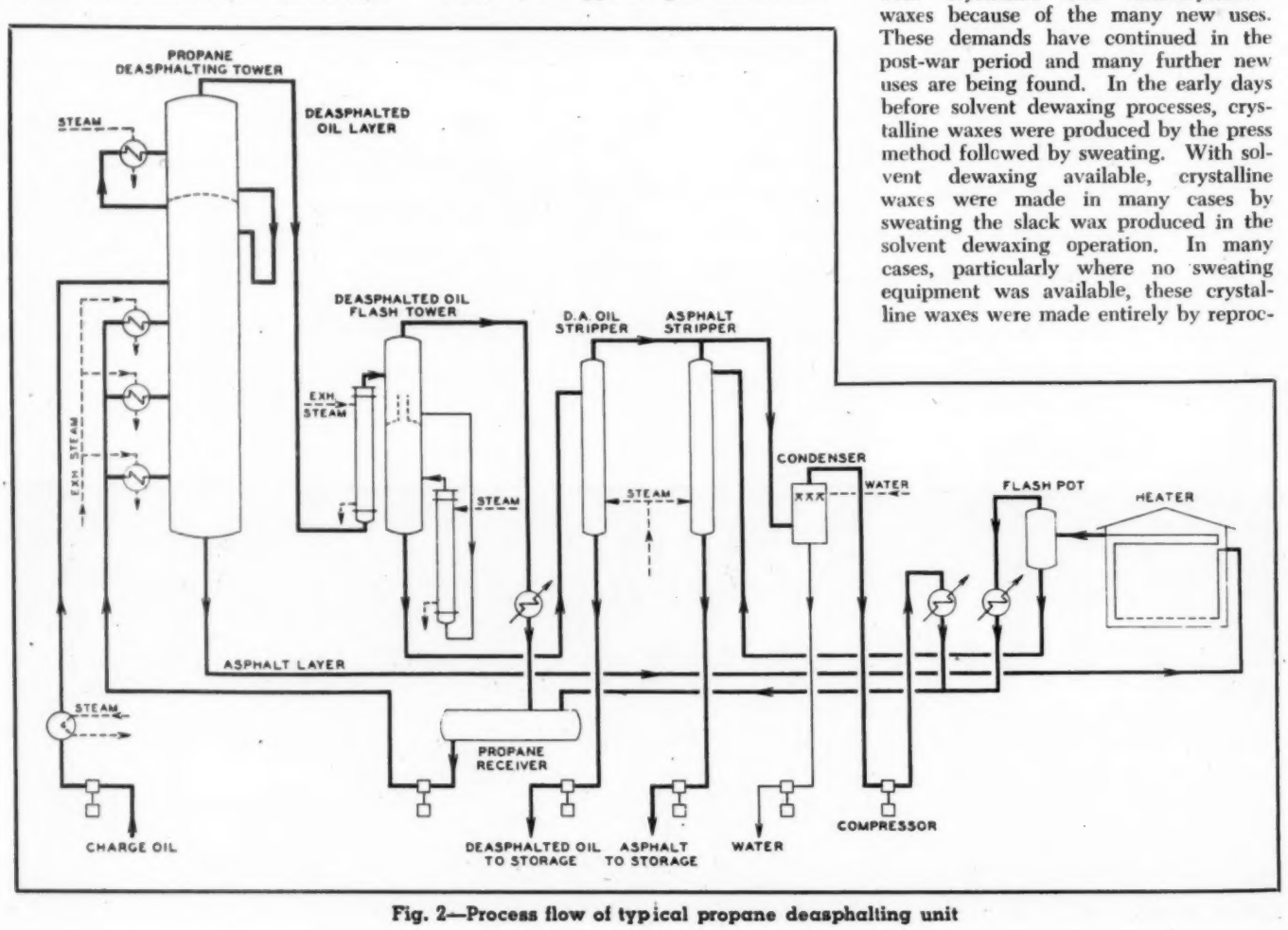


Fig. 2—Process flow of typical propane deasphalting unit

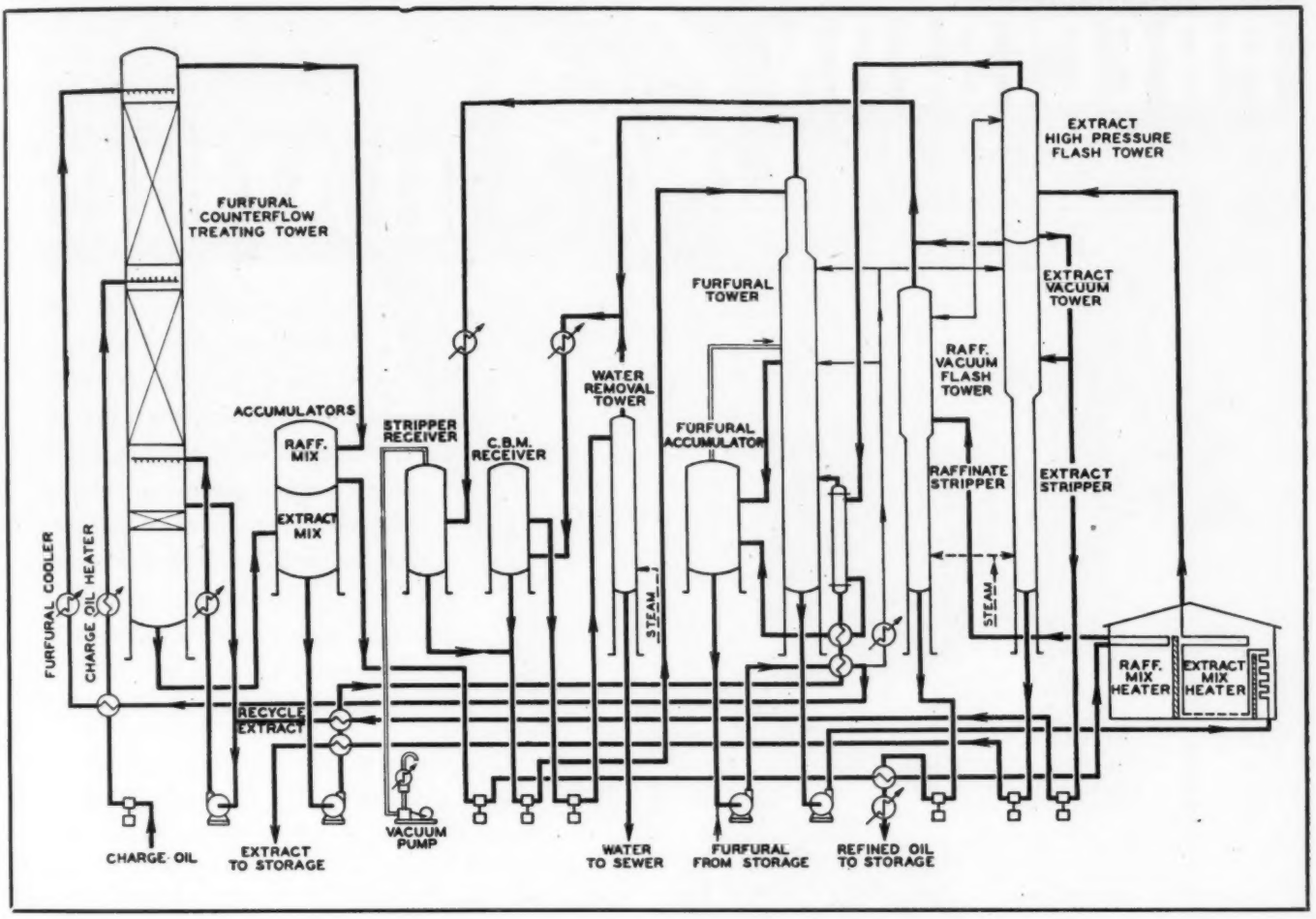


Fig. 3—Flow diagram for the furfural solvent refining process

essing through the solvent dewaxing plant. Where sweating equipment was available with insufficient capacity, the emulsion deoiling process has been used to deoil the slack wax from either presses or solvent dewaxing operations to reduce the oil content sufficiently so that the production from the existing sweater became optimum.

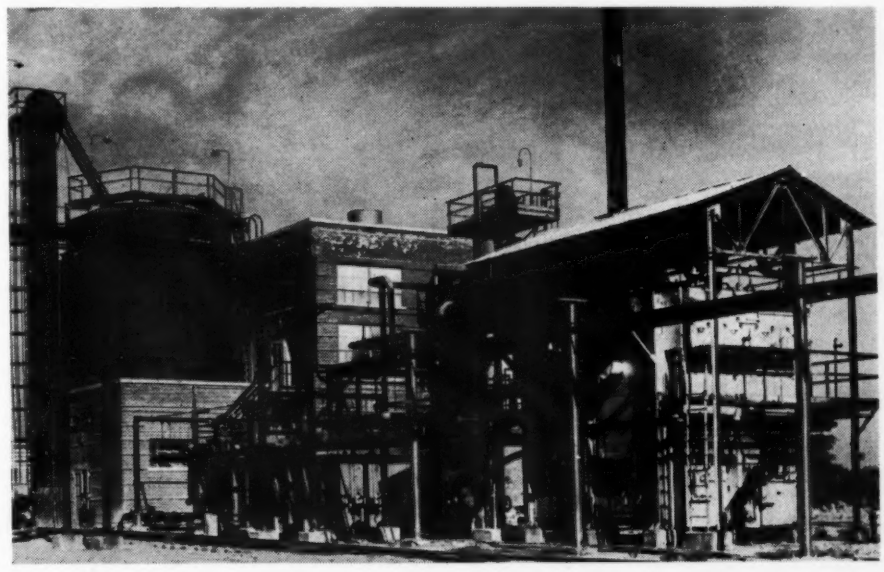
Micro-crystalline wax, on the other hand, has been made almost exclusively by solvent deoiling. The charge slack wax during the early 30's was primarily made from centrifuging heavy lube stocks, while in the late 30's and the war period the charge became more and more the slack wax from solvent dewaxing. Almost all the new micro-crystalline waxes will be made by solvent processes. All these waxes are generally finished by clay or bone black percolation for color and odor requirements. In many cases acid treating of waxes is still used in order to meet stringent requirements for odor, color and stability.

Clay Finishing

The final processing step in most lubricating oil refineries is treatment of the lube oils with activated clay by either of two methods—continuous contacting with finely divided clay or percolation through beds of granular clay.

Continuous contacting is a completely continuous operation, with fresh clay being added and spent clay being discarded at all times. The treated oil is of uniform quality and is produced at a steady rate. The disadvantage of this process lies in the fact that the consumption of clay and therefore the direct operating costs are high.

The percolation process is essentially a batch operation since oil is pumped



Clay contacting plant. Fresh clay unloading elevator with storage next to it is shown at left. Filter building is in background. Right foreground is contacting heater

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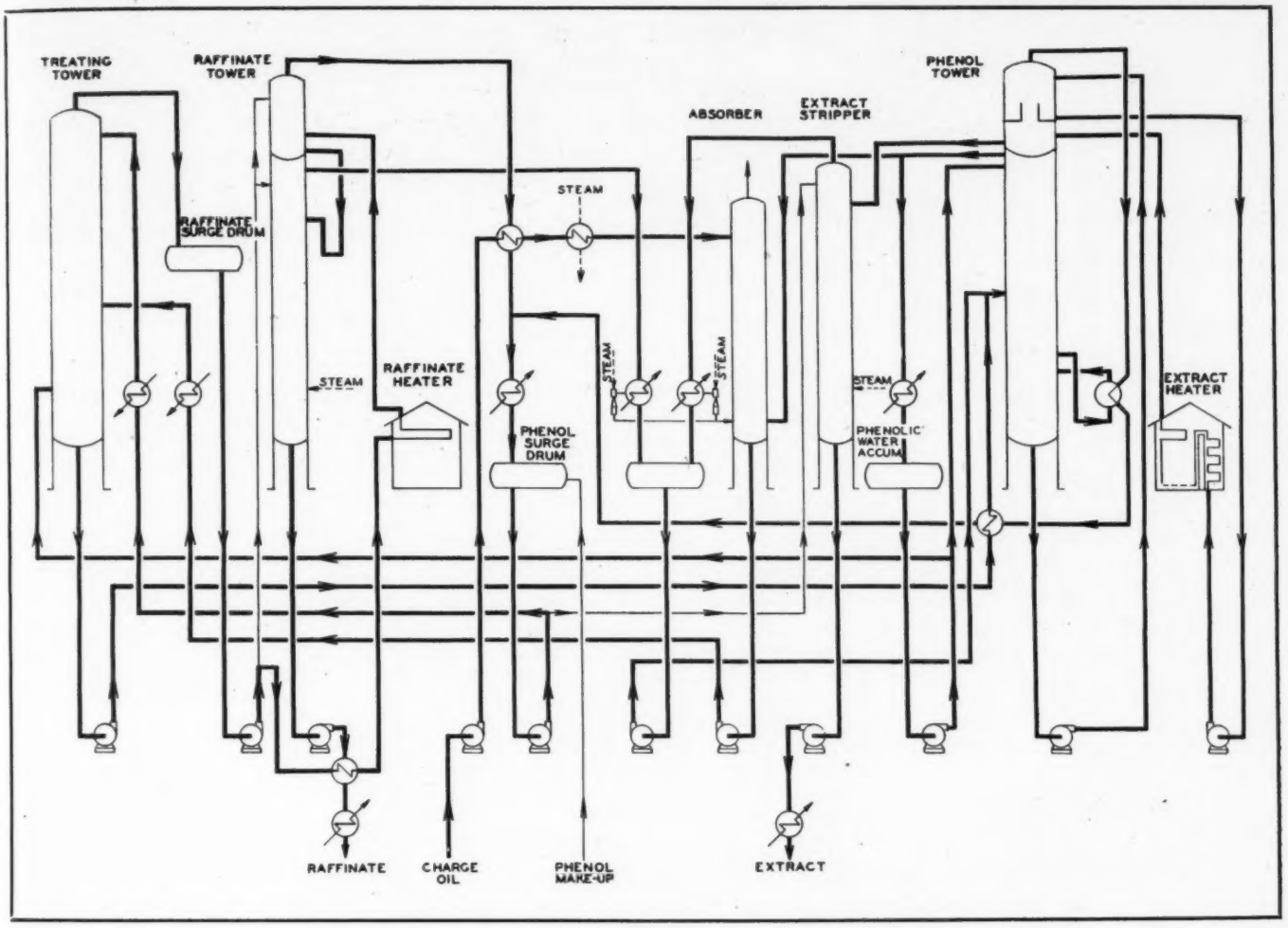


Fig. 4—Flow diagram for the phenol solvent refining process

through a fixed bed of granular clay until the activity of the clay is reduced to an uneconomical level. At this point a fresh bed of clay is put into operation. One disadvantage to this process is the fact that the quality of the oil produced is variable. The oil filtering through the fresh clay is of extra good quality and shows a quality decrease as the clay becomes deactivated. The use of a number of filters in series tends to minimize this effect but increases investment.

An advantage of the percolation process is the fact that the clay may be regenerated and used many times, thus making the operating cost lower than with contacting. Regeneration is accomplished by any one of a number of types of clay burning furnaces, whereby color bodies and other contaminants are burned from the clay pellets.

New developments in the field of clay treatment have been mostly connected with the clay contacting process and include the use of continuous rotary vacuum filters for the separation of clay and oil, the addition of sweetening and drying equipment after the filter for improvement of odor and haze, and the development of low-cost clays. Plants of both types are being built at the present time, the selection of which is influenced by economics and results as well as the refiner's own preferences and experiences.

In general, the economics show lower investment and higher operating costs for the contacting process, higher investment and lower operating costs for the percolation process. The possibility of recovering spent contact clay has always received considerable attention but until now very few plants have found it feasible to do this. One refiner has been employing a solvent for the reactivation of spent magnesol, as part of their clay contacting of lube oils.

Compounding and Blending

An interesting but unusual situation in lube oil refineries is the existence among the many brand new processing facilities of compounding and blending plants which, for the most part, are more than 20 years old. In a few installations,

TABLE 4—Lube Plant Material Balance

	Gas Oil	Light Neutral	Light Lube Dist.	Medium Lube Dist.	Short Residue	Total
Per cent on Crude	5.0	5.0	5.0	7.0	17.0	39.0
				BPCD		
Vacuum Tower Cuts	634	634	634	886	2152	4940
Propane D.A. Chge.	...	...	...	...	2152	2152
Asphalt	...	...	..	...	860	860
Deasphalted Oil	...	...	...	...	1292	1292
Solvent Refining Chge.	...	...	634	886	1292	2812
Extract	...	...	191	266	413	870
Raffinate	...	...	443	620	879	1942
Solvent Dewaxing Chge.	...	634	443	620	879	2576
Hard Wax	...	54	55	83	88	280
Slop Wax	...	54	27	41	88	210
Dewaxed Oil	...	526	361	496	703	2086
Clay Contacting Loss	...	16	15	20	35	86
Finished Oil	...	510	346	476	668	2000

Overall yield of finished lube oils—15.8% on crude.

erected for blending, packaging and loading lube products. It is probable that many other worn out blending plants will be replaced in the near future, and it is certainly of interest to the refiner to note several new developments in this field.

As far as blending process equipment is concerned, more and more emphasis has been placed on continuous as opposed to batch blending. Several machines are on the market specifically designed to continuously blend lubricating oils and additives speedily and accurately. Coupled with the blending machine in some cases is a provision for dehydrating or dehazing the oil. Another trend is toward the elimination of elaborate valving manifolds by the use of flexible synthetic rubber hose connections. This step, in addition to reducing the expenditure for valves, also minimizes the possibility of contamination which is a serious problem in lube oil blending.

In the general layout of the packaging, storage and loading sections of the plant, advantage can be taken of many recent developments in industrial engineering. It is generally found economical to supplant manual labor as far as possible with automatic conveyors, lift trucks, elevators, etc. The layout of such equipment for maximum efficiency is very important.

In connection with the blending phase of lubricating oil manufacture, it should be noted that the use of additives in regular and premium grade motor oil is receiving increasing attention. Whereas additives have been developed for some time in the past, their use was principally confined to heavy-duty and specialty oils. Since they have been very effective in improving both the chemical and physical properties of heavy duty oils, there is a definite trend at the present time to incorporate additives in other types of oil such as that used in aircraft engines, automobiles, and diesel engines. Since new engine design is always in however, up-to-date plants are being the direction of increasingly severe service requirements for lubricating oil, it is reasonable to assume that more and more additives will be developed and used.

TABLE 5—Direct Operating Costs

	$/CD	c/Bbl. Chge.
Vacuum Distillation ...	364	7.4
Propane Deasphalting ..	293	13.6
Solvent Refining	532	18.9
MEK Solvent Dewaxing.	714	27.7
Clay Treating	574	27.5
General Refinery	414	...
Total	2891	...

Investments

Total Process Units*	$ 7,230,000
Outside Facilities (Tankage, Yard Piping, Utilities)	$ 3,600,000
Total Equipment	$10,830,000
Paid-up Royalties	$ 385,000
Total Capital Investment ...	$11,215,000

*Vacuum Distillation
Propane Deasphalting
Solvent Refining
Solvent Dewaxing and Wax Deoiling
Clay Contacting

Synthetic Lubricants

No discussion of developments in lubricating oil manufacture would be complete without mentioning synthetic lubricants. Research has been carried on for a number of years both in this country and abroad, and during World War II some remarkable developments have taken place in the commercial production of these materials. In Germany a number of fairly large scale plants were built and operated as a matter of necessity when their supplies of crude oil were virtually cut off. A total production of about 1500 b/d of synthetic lubricating oil was planned, but the maximum actual production reached a figure of about 650 b/d.

These German synthetic lubes were manufactured by the polymerization of ethylene using an aluminum chloride catalyst, and purified by steam distillation and treatment with Fuller's earth. The properties of the oils made were excellent with viscosity indices up to about 115 and Conradson carbon residues of about 0.2%. These oils were used principally as aviation lubes, usually in blend of about half petroleum lube oils.

There is a limited production of syn-

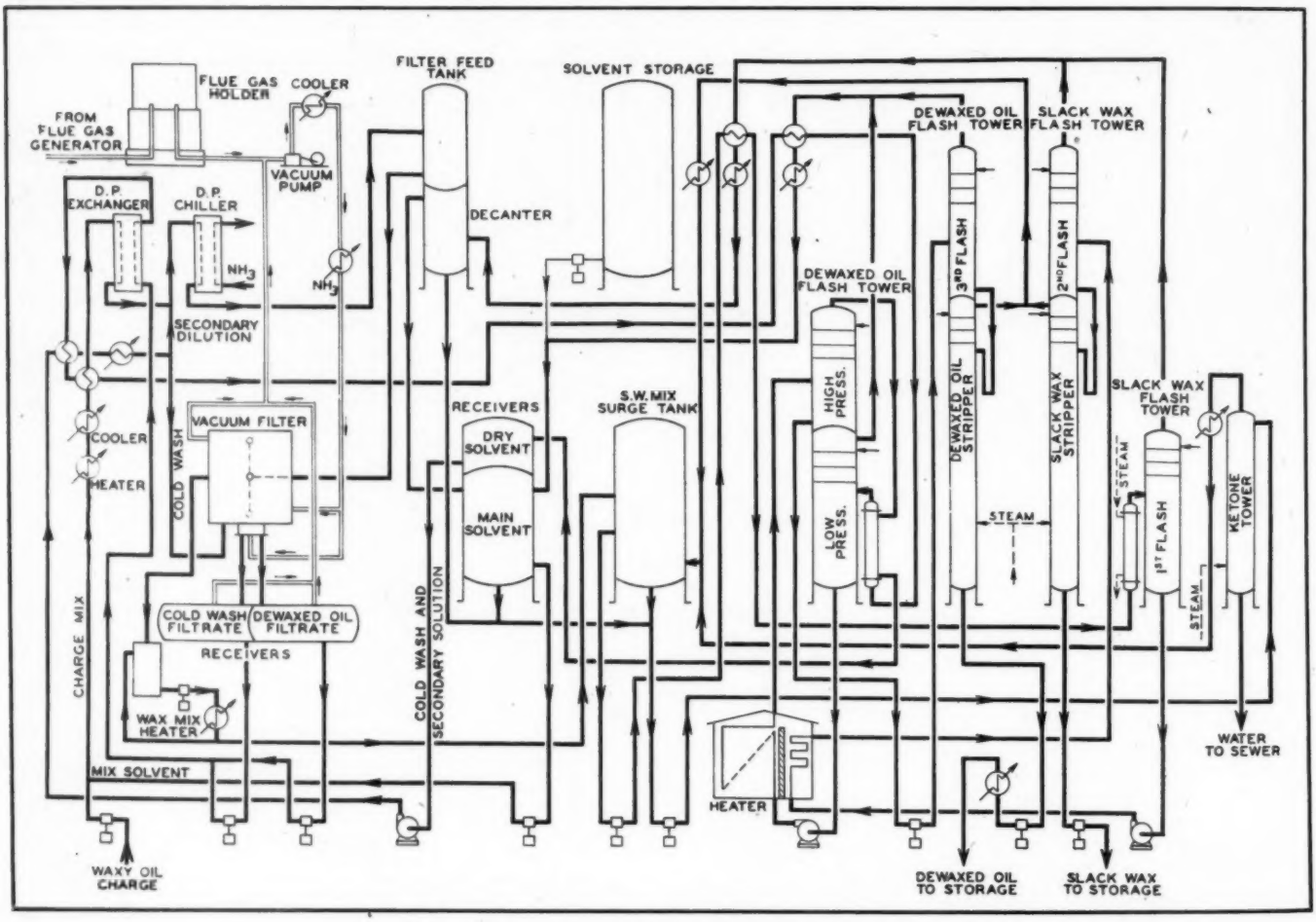
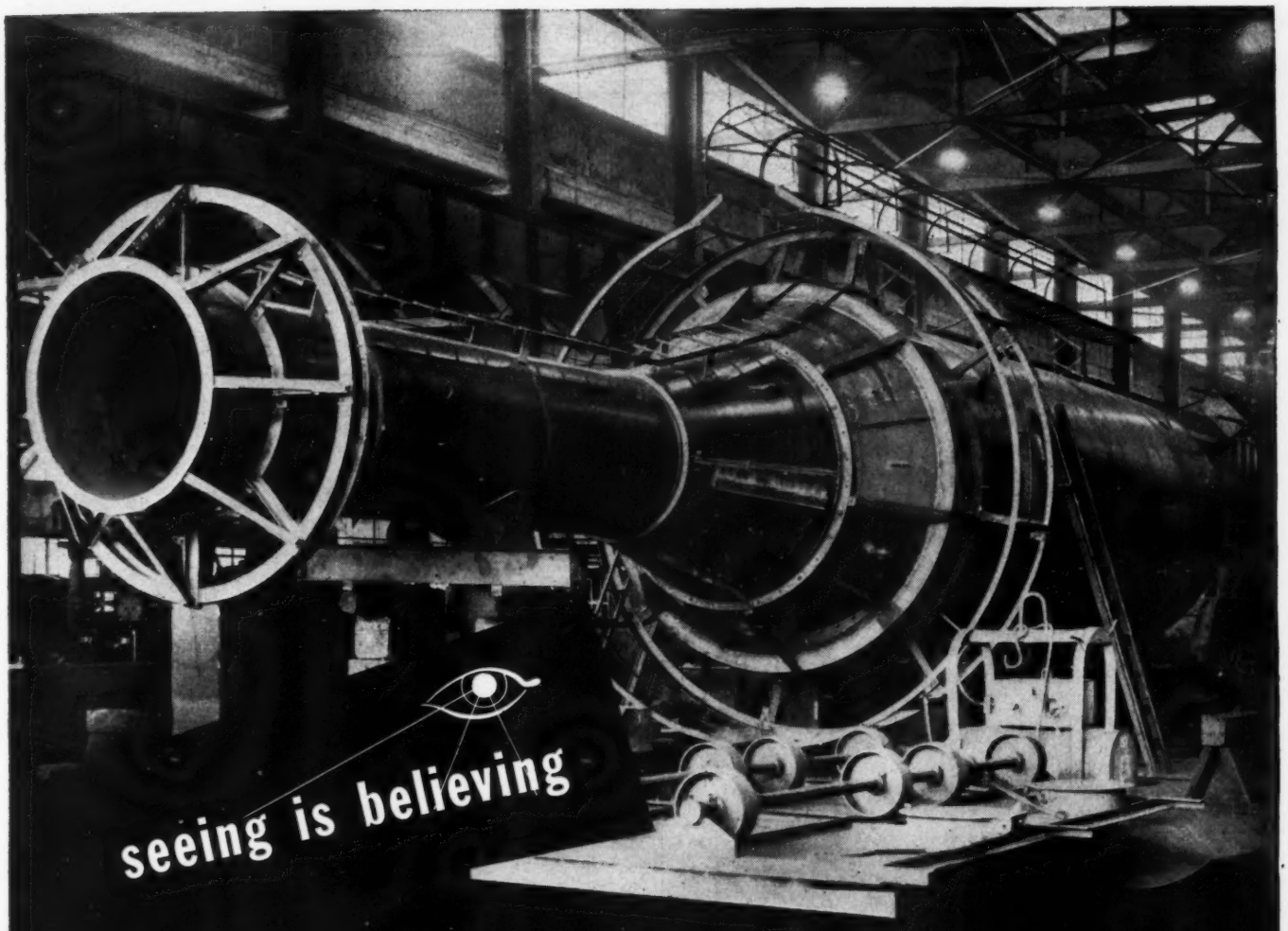


Fig. 5—Process flow of a benzol-ketone dewaxing unit



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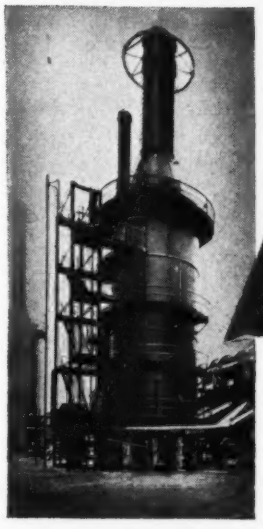

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thetic lubricating oils in the U. S. at the present time. These oils are produced by chemical synthesis from natural or other hydrocarbon gases. A number of grades has been made ranging in viscosity from 45 to 105 SSU at 210° F. The quality of these oils apparently is superior to the best petroleum lube oils with viscosity indices of 140 or higher and carbon residues less than .01%. Manufacturing costs for these synthetic oils are very high and the resulting high selling price restricts their use to special markets, and they are not at present competitive with oils from petroleum sources.

Economics

Most refiners and particularly those who are contemplating the installation of new lube oil facilities are interested in such information as investment costs, operating costs, approximate return on the investment for such installations as a complete lube oil manufacturing plant. It is rather difficult to present such figures which will apply for each specific case in which a refiner may be interested, but the authors have felt that some general discussion along this line would be of some value. For this reason a typical modern lube oil operation was selected for the production of 2000 b/d of 95 V. I. zero pour lubes from a Mid-Continent type crude.

Assuming full utilization of all lube fractions present in the crude, the overall refining yield picture indicates a requirement of approximately 12,700 b/d of crude. Thus the yield of finished lubricating oil amounts to 15.8% of the crude. The processing route suggested would call for charging 4940 b/d of 39% reduced crude to a vacuum distillation unit which would produce simultaneously a gas oil overhead, three lube distillates as side streams, and a short residue. The residue would be charged to a propane deasphalting unit with a yield of about 60% of deasphalted oil.

The three distillate stocks and the deasphalted bottoms would be processed successively through a single solvent refining unit, a combined solvent dewaxing and wax deciling unit, and a clay finishing unit. The overall material balance for this operation is outlined in Table 4. It will be noted that in addition to the finished oils, 280 b/d of "hard wax" constitutes another valuable product from this plant. This term is given to wax, both crystalline and micro-crystalline, which has been deoiled to less than 1% oil, by means of the solvent process. By-products from the plant include 860 b/d of propane asphalt, 870 b/d of solvent extract, and 210 b/d of slop wax.

Table 5 summarizes approximate direct operating costs and capital investments for the various processing units as well as refinery auxiliaries directly connected with the lube plant. The operating costs include utilities, solvents, clay, and operating manpower; the investments include total erected equipment cost together with paid-up royalties for the licensed processes (propane deasphalting, solvent refining and solvent dewaxing).

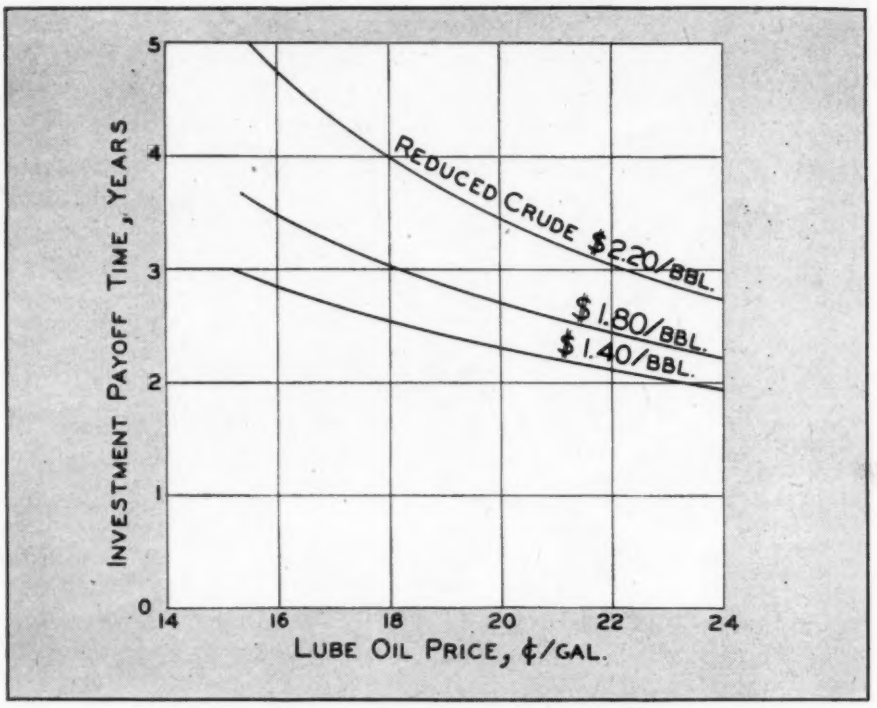


Fig. 6—Effect of reduced crude and lube product prices on plant investment payoff time

Using these costs and prevailing refinery prices for products in the Mid-Continent area, an economic picture has been set up in Table 6. The value of the reduced crude has been assumed to be the same as for crude. This figure will vary from case to case, depending on the method the refiner uses in establishing the value of intermediate products, but the assumed value is believed to be conservative. Fixed charges, including maintenance, taxes, insurance, and interest on the investment have been added to charge stock and direct operating costs.

As shown in Table 6, the investment for this plant will be paid off in 2.4 years, with no amortization included in expenses. Fig. 6 shows the effect on investment pay-off time of variations in charge stock and principal product prices. This indicates the profitability of this plant even under drastic crude price increases and finished oil price decreases.

The increasing activity in the installation of modern solvent deasphalting, refining, and dewaxing facilities for the production of premium lubricating oils since the end of World War II continues to the time of writing of this paper. This is accounted for by a catching up of this construction delayed by the war as well as by the normal demand increases, both for quantity and increased quality of product. Definite trends in the selection of processes are apparent and a reasonable return on the investment for these plants justifies the program now being carried out.

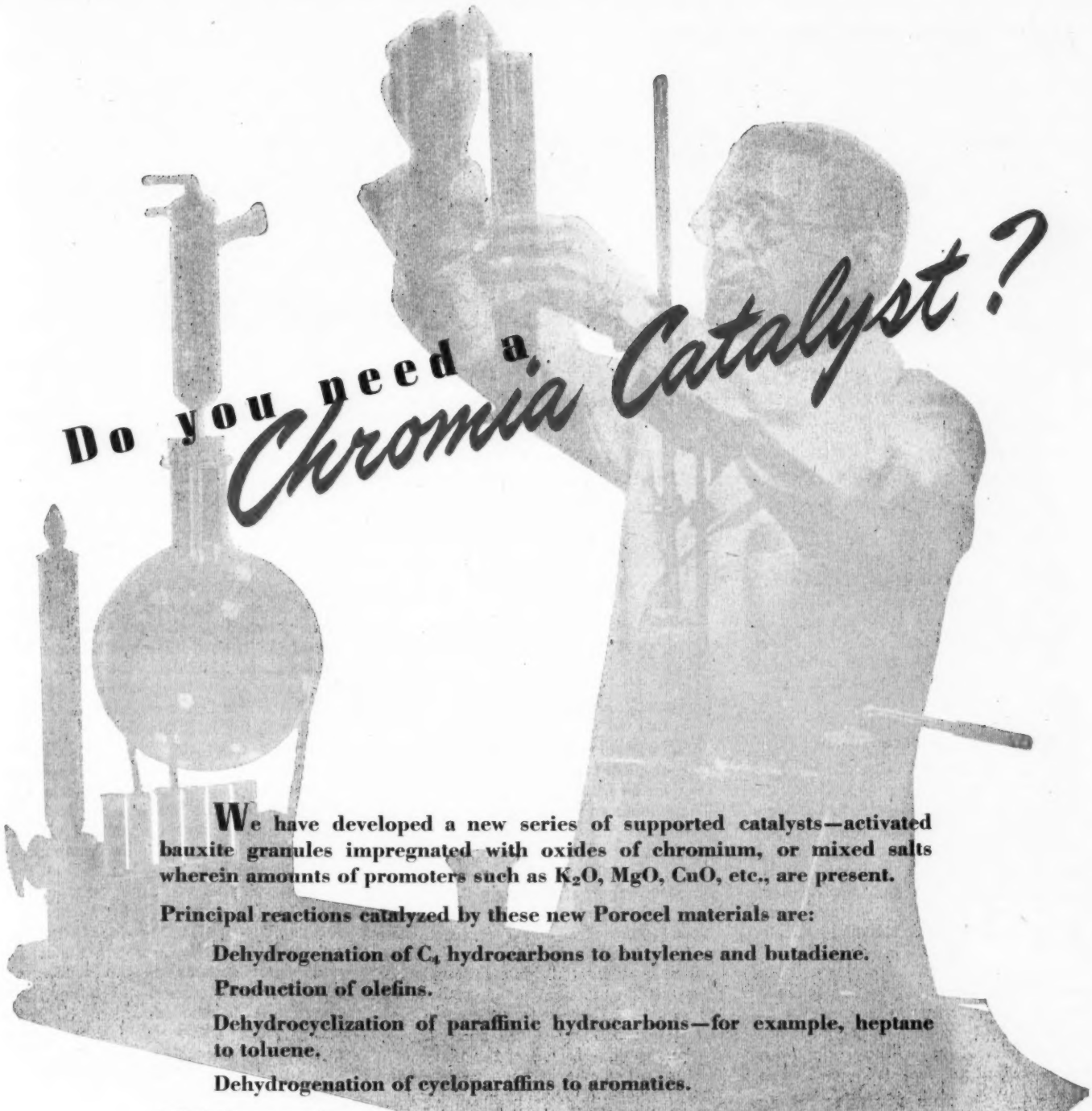
TABLE 6—Summary of Economics

Operating Revenue

Income from Products	Unit Price	BPCD	$ CD	
95 V.I., Zero Pour Lubes	22c/gal.	1490	13,750	
Light Neutral Oil	15c/gal.	510	3,210	
122-132° F. M.P. Wax	8c/lb.	192	4,600	
Micro-Crystalline Wax	6c/lb.	88	1,670	
Gas Oil	$2.00/bbl.	634	1,270	
Fuel Oil	1.50/bbl.	1940	2,910	
				$27,410

Operating Expenses

	$/CD	
Reduced Crude @ $1.80/bbl.	8,900	
Direct Operating Costs (Table 5)	2,891	
Maintenance @ 3% of Equipment Investment	890	
Interest @ 6% of Capital Investment	1,850	
Taxes & Insurance @ 0.4% of Equipment	120	
		$14,651
Net Daily Profit, no Amortization		12,759
Pay-off on Investment, Days	880	
Years	2.4	



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GRAPHICAL METHOD for DISTILLATION CALCULATIONS

A graphical arrangement is presented for performing plate-to-plate distillation calculations. The method is the equivalent of the common algebraic procedure and can be used for any number of components. Advantages are the speed with which the calculations can be performed and the ease of visualization because of the graphical form.

By W. D. HARBERT
Lion Oil Company

A STANDARD method of calculation in distillation design is the so-called "plate-to-plate" method which has been completely described in the literature[2, 3, 4, 5, 6]. This method is based on the concept of the equilibrium plate, which is considered to be a perfect contact between the counter-flowing liquid and vapor streams of the column.

In the use of this plate-to-plate procedure for the design of a distillation operation it is first necessary to know the feed charge to the unit and the separations that are desired. A tower pressure is chosen based on the properties of the products and the temperatures available for the condenser and reboiler. A reasonable reflux rate is selected depending on the difficulty of the separation. From these values the complete conditions of temperature, pressure and composition at the top and bottom of the column are determined by heat and material balances around the column and by equilibrium calculations at the ends of the column.

The plate-to-plate procedure for the part of the column above the feed inlet begins at the known top plate and calculates the plate conditions downwards, plate by plate, from liquid to vapor to liquid, by the alternate use of the plate material balances and equilibrium relationships. A corresponding calculation is made from the bottom plate or reboiler upwards. A feed plate is selected at which the calculated compositions from above and below check. The final answer obtained is the numbers of plates above and below the feed inlet necessary to give the desired separation.

Equations Used in Calculations

The basic equations used in the plate-to-plate calculations are as follows (see nomenclature):

Vapor-liquid equilibrium relationship

$$y = Kx \quad \ldots\ldots (1)$$

or

$$(Vy)_n = (VK/L)\ (Lx)_{n+1} \quad \ldots\ldots (2)$$

Component material balance above the feed inlet

$$(Vy)_n = (Lx)_n + Dx_D \quad \ldots\ldots (3)$$

Component material balance below the feed inlet

$$(L'x)_m = (V'y)_m + Bx_B \quad \ldots\ldots (4)$$

Composition summations

$$\Sigma(Lx) = L;\ \Sigma(Vy) = V \quad \ldots\ldots (5)$$

In order to use these equations in the plate-to-plate procedure for above the feed inlet certain values must be known. The amount and composition of the overhead product stream gives values of Dx_D required for use in Equation 3. A complete composition of one stream, either liquid or vapor, at the top plate is necessary as a starting point for the calculations. Values of L and V for each plate must be known and these may be determined by individual plate heat balances. For many distillation columns, however, these internal reflux values remain relatively constant and so can be considered to be the same for all of the plates of a section of column. For convenience the known values of Dx_D, Lx, V, etc. should all be for a single material basis, such as 100 mols of liquid overflow from a plate.

In addition to these, of course, it is necessary to have complete vapor-liquid equilibrium data, preferably in the form of K values, for the temperature range of the section of column.

The detailed steps of one algebraic procedure for going plate-to-plate down a column from a known liquid stream are as follows:

Step 1. With the known liquid to the plate and the known overhead obtain the vapor from the plate by means of Equation 3. Values of Lx and of Dx_D are added to give values of Vy for the vapor from the plate (Equation 3).

Step 2. With Equation 2 and the equilibrium data obtain the liquid leaving the plate in equilibrium with the known vapor stream. A temperature is assumed for the plate equilibrium and values of Vy, L/V and K are substituted in Equation 2 so as to obtain a value of Lx for each of the components. These Lx's are then summed to give the total mols of liquid, L. If the difference between the original and calculated values of L is too large then a new temperature is assumed and the calculation is repeated. If the difference in the L values is small then the calculated Lx's can be simply increased or decreased proportionally so as to total the desired L. This is the equivalent of assuming that the ratios of the K values remain constant with temperature.[4] The final values of Lx give the composition and overflow from the plate.

It is seen that the answer obtained in Step 2, a known plate liquid, is the starting point in Step 1. These two steps are repeated alternately to obtain the liquid and vapor streams of the succeeding plates down the column until a feed plate composition is reached.

The plate-to-plate calculations up the column from the still are similar. The amount and composition of the bottoms product (the still liquid) are known, and values of L' and V' can be determined. The composition of the vapor leaving the still in equilibrium with the still liquid is found with Equation 2 as in Step 2 above. The composition of the liquid to the still from the bottom plate is then obtained with Equation 4. This corresponds to Step 1 above. These calculations are repeated alternately plate-by-plate up the column until a feed plate composition is reached.

The final answers obtained from this plate-to-plate procedure are the numbers of plates above and below the feed inlet required for the desired separation at the given reflux rates. The calculations just described are commonly performed algebraically in tabular form. It is, however, possible to perform exactly the same mathematical operations graphically. The construction and procedure for doing this is the subject of this article.

Conditions for Example

The graphical method of calculating

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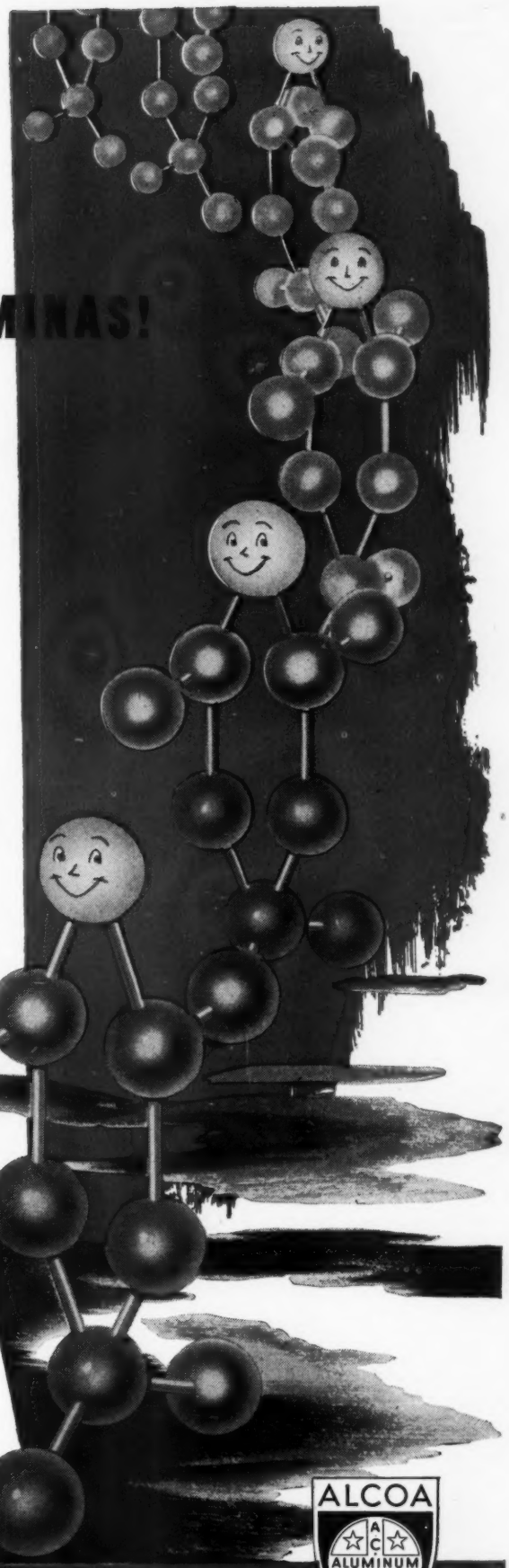

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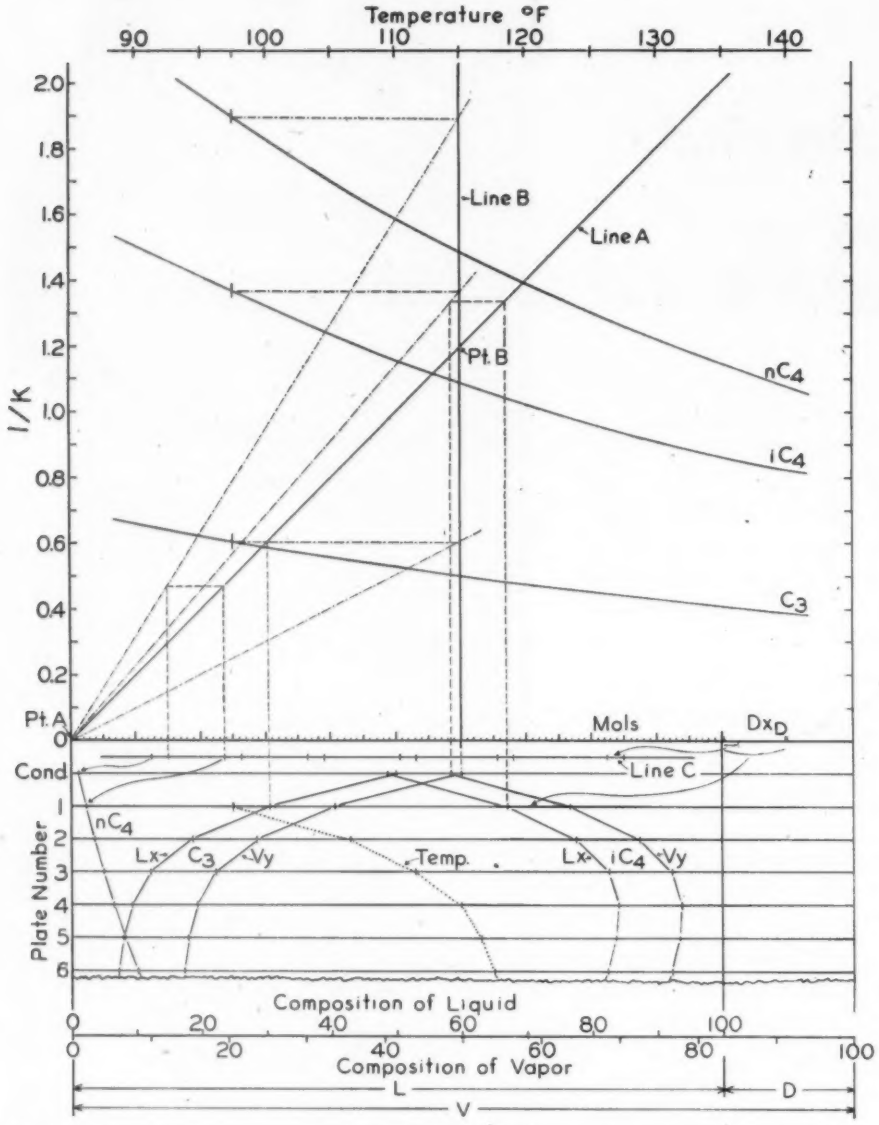

Fig. 1—Graphical arrangement for calculating plate-to-plate down the column from the condenser for the conditions of the example. See text for construction and procedure

plate-to-plate, corresponding to the algebraic method just described, will be presented by example for a distillation column designed to split between normal and isobutanes. The feed to this column and the desired products are as follows:

Component	—Mols per 100 Mols Feed— Feed	Overhead	Bottoms
Propane	20.0	20.0	...
Iso-butane	20.0	19.5	0.5
n-butane	20.0	0.5	19.5
Iso-pentane	20.0	...	20.0
n-pentane	20.0	...	20.0
Total	100.0	40.0	60.0

The tower pressure is to be 100 psia. The overhead vapors are totally condensed and the reflux is returned to the tower at its boiling point. Then the compositions of the overhead vapor, the overhead product, and the reflux are the same. From the heat and material balances it is found that if five parts of overhead condensate are returned to the tower as reflux for each one that is withdrawn as product, then L/V for above the feed will be 0.833 and L'/V' for below the feed will be 1.25. This reflux is selected for the design calculation, and the values $L/V = 0.833$ and $L'/V' = 1.25$ are assumed to be constant for all of the plates of the sections of column above and below the feed.

For above the feed plate the material basis for the calculation is taken as 100 mols of liquid overflow from the plates, i.e. $L = 100$. But $L/V = 0.833$, so that $V = 120$ and $D = V - L = 20$. For below the feed inlet the basis of calculation is taken as 100 mols of vapor, i.e. $V' = 100$. But $L'/V' = 1.25$, so that $L' = 125$ and $B = L' - V' = 25$. For above the feed inlet the known stream composition required as a starting point is taken as the hot reflux to the top plate, which is the same as the overhead product. For below the feed inlet the known stream is taken as the liquid in the still, which is the same as the bottoms product. The amounts and compositions of these two streams, together with the product streams, must be expressed in terms of the material bases chosen. These values are given in Table 1.

These compositions are the starting points of the plate-to-plate calculations. The composition of the still liquid is only used to determine the composition of the vapor from the still. Then the actual amount of this liquid is unimportant, and 125 mols is selected as being the most convenient amount.

Graphical Constructions

In performing the plate-to-plate calculations the first step is to set up the proper graphical construction. These constructions for above and below the feed inlet for the conditions of the example are described in detail in the following paragraphs and are illustrated in Figs. 1 and 2. For above the feed inlet (Fig. 1) the steps are as follows:

Step 1. Set up on a large sheet of graph paper a coordinate plot of $1/K$ vs. mols. The 0-0 point of the coordinates is labelled Point A as shown. The $1/K$ scale covers the values of $1/K$ for all the components for the range of plate temperatures above the feed. The mol scale is marked from 0 to 100 as shown.

Step 2. Construct a temperature scale and plot $1/K$ vs. T for the components for the temperature range of the tower. This temperature scale is shown at the top of Fig. 1, and the lines of $1/K$ vs. T are labelled with the corresponding components. The K values at 100 psia are from Reference 1.

Step 3. Construct Line A through point A at a 45° angle with the coordinates as shown on Fig. 1. Locate Point B on Line A at a value on the $1/K$ scale of $V/L = 1.0/0.833 = 1.20$. Through this Point B construct vertical Line B.

Step 4. Draw a series of composition lines for the plates parallel to and below the mol axis. These are labelled with the numbers of the succeeding plates to be calculated. Length on these lines represents mols as measured on the 0-100 mol scale. On Fig. 1 the values $L = 100$ mols and $V = 120$ mols are marked off for all of the plates above the feed.

Step 5. Arrange to rotate a straightedge through Point A. An ordinary transparent

TABLE 1 — Compositions of Streams Used as Starting Points in Example of Plate-to-Plate Calculations

	Reflux to Top Plate $(Lx)_n$	Overhead Product Dx_D	Still Liquid $(Lx)_B$	Bottoms Product Bx_B
Propane	50.00	10.00	....	....
Iso-butane	48.75	9.75	1.04	.21
n-butane	1.25	0.25	40.62	8.13
Iso-pentane	....	....	41.67	8.33
n-pentane	....	....	41.67	8.33
Total Mols	100.00	20.00	125.00	25.00

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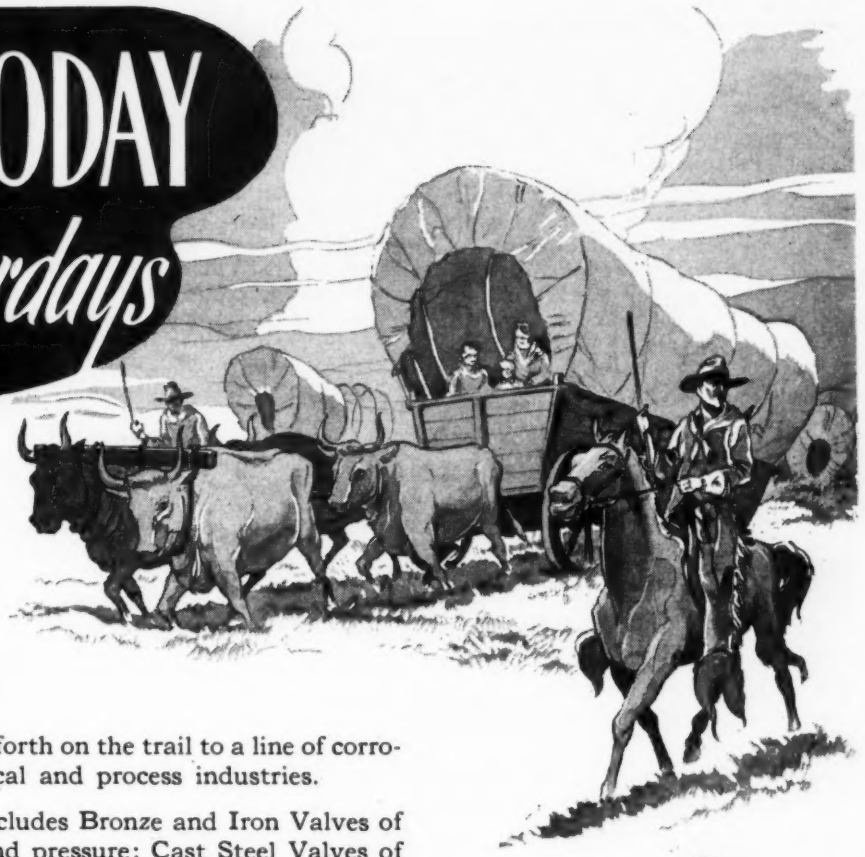

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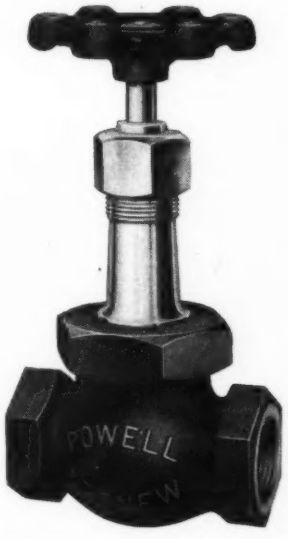

Fig. 190—150-pound Iron Body Bronze Mounted "Irenew" Globe Valve. Has screwed ends, union bonnet and regrindable, renewable, wear-resisting "Powellium" nickel-bronze seat and disc.

Fig. 1561—Class 150-pound Cast Steel Swing Check Valve. with flanged ends and bolted cap. Disc, when wide open, permits full unobstructed flow through the valve body.

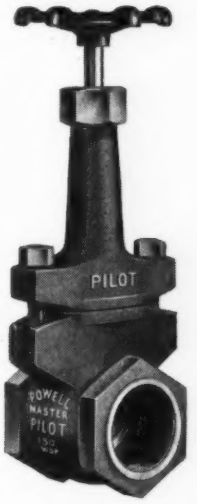

Fig. 1460—Iron Body Bronze Mounted "Master Pilot" Gate Valve. Screwed ends, rising stem, bolted flanged bonnet and taper wedge solid disc. Also available in All Iron.

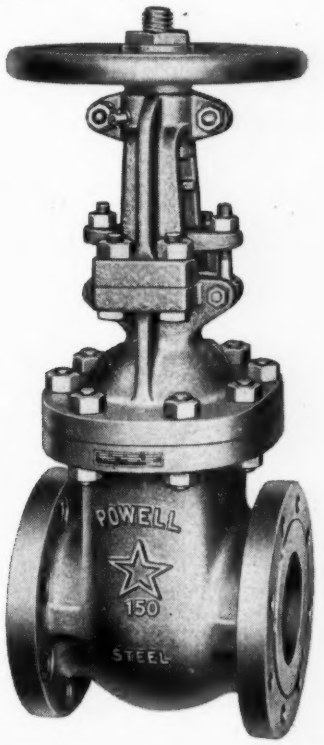

Fig. 1503—Class 150-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc.

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triangle and a thumb tack at Point A are satisfactory for this.

All of these construction details except Step 5 are illustrated on Fig. 1.

The corresponding construction for calculating plate-to-plate for below the feed inlet is shown in Fig. 2. A coordinate plot of values of K vs. mols is set up as shown with the 0-0 point labelled Point A. A temperature scale is constructed and values of K vs. T (from Reference 1) are plotted for the components. Line A is drawn through Point A at an angle of 45° as shown. Point B is located on this line at a value of $K = L'/V' = 1.25$, and Line B is drawn vertically through this point. A scale of 0 to 100 mols is marked off on the composition axis. Lines parallel to this axis are drawn for the individual plates as shown, and the constant values $L' = 125$ and $V' = 100$ are marked off on them. A transparent straightedge is arranged to rotate about Point A.

Graphical Procedure

The graphical procedure for calculating plate-to-plate with the above construction is described below and is illustrated in Fig. 1. As a starting point the values of Lx for the components in the reflux liquid, as tabulated under "Conditions for Example," are plotted on the line labelled "Condenser." And for convenience the values of Dx_D for the components are marked off at the end of the composition axis. For iso-butane these values are $(Lx)_c = 48.75$ and $Dx_D = 9.75$ as shown on Fig. 1.

The steps for the calculation of the top plate of the column are given below. These correspond to the steps of the algebraic procedure already described.

Step 1. With the known liquid to the plate and the known overhead product obtain the vapor from the plate by means of Equation 3. With a pair of calipers add the mol lengths of Dx_D for the components to the corresponding values of $(Lx)_c$ and mark the results on the condenser composition line. These lengths represent mols of vapor, Vy, to the condenser from the top plate of the column. This step corresponds to the addition of Equation 3.

As an example, for iso-butane $(Lx)_c = 48.75$ and $Dx_D = 9.75$, and these added wih calipers give $(Vy)_c = 58.50$ for the mols of iso-butane in the vapor to the condenser. This value is marked off on the condenser composition line.

Step 2. With Equation 2 obtain the mols of the components in the liquid leaving the plate in equilibrium with the known vapor stream of Step 1.

First, a temperature for the top plate is estimated so as to obtain values of K. Next, the values of Vy from Step 1 are multiplied graphically by values of L/VK so as to give values of Lx (Equation 2). To do this for one component the straightedge rotating around Point A is set through the point on Line B at the value of $1/K$ for the component at the estimated plate temperature. This operation is shown by the dot-dash lines of Fig. 1. Then begin at the value of Vy for the component from Step 1 and go vertically upward to the straightedge, horizontally across to Line A, and vertically downward to the composition line for Plate 1. This operation is shown by the dashed lines of Fig. 1. The result is a value of $(Lx)_1$ for the component marked off on the Plate 1 composition line. It will be proved later that this operation gives the multiplication of Equation 2. Values of $(Lx)_1$ for all of the components are obtained in this way and are summed with calipers to give a value for total liquid mols, L_1. If this calculated L differs too much from the original assumed L, then a new plate temperature can be chosen and the calculation repeated. Or if the calculated and assumed L's are close then the individual values of Lx can be simply increased or decreased proportionally to give the desired total L. This is the equivalent of the assumption of constant ratios of K values for the small temperature range involved. In this way values of Lx for the components in the liquid from the top tray are obtained.

As an example, a temperature of 97.5° F. is assumed for the top plate, and $1/K$ for iso-butane at this temperature is seen to be 1.37. The straightedge rotating through Point A is set at this value on Line B as shown. Then from the value of $Vy = 58.50$ for iso-butane in the vapors to the condenser go vertically upwards to the rotating straightedge, horizontally across to Line A, and vertically down to obtain a value of $Lx = 67.0$ mols as marked off on the composition line for Plate 1. The corresponding value obtained for propane is $Lx = 30.4$ and for n-butane is $Lx = 2.4$. These total 99.8 which is very near to the desired $L = 100$ so that no further adjustments are necessary. Then 67.0 mols of iso-butane are in the liquid overflow from the top tray.

The result of this second step, then, is a known liquid stream to a plate, and this was the beginning point in the first step.

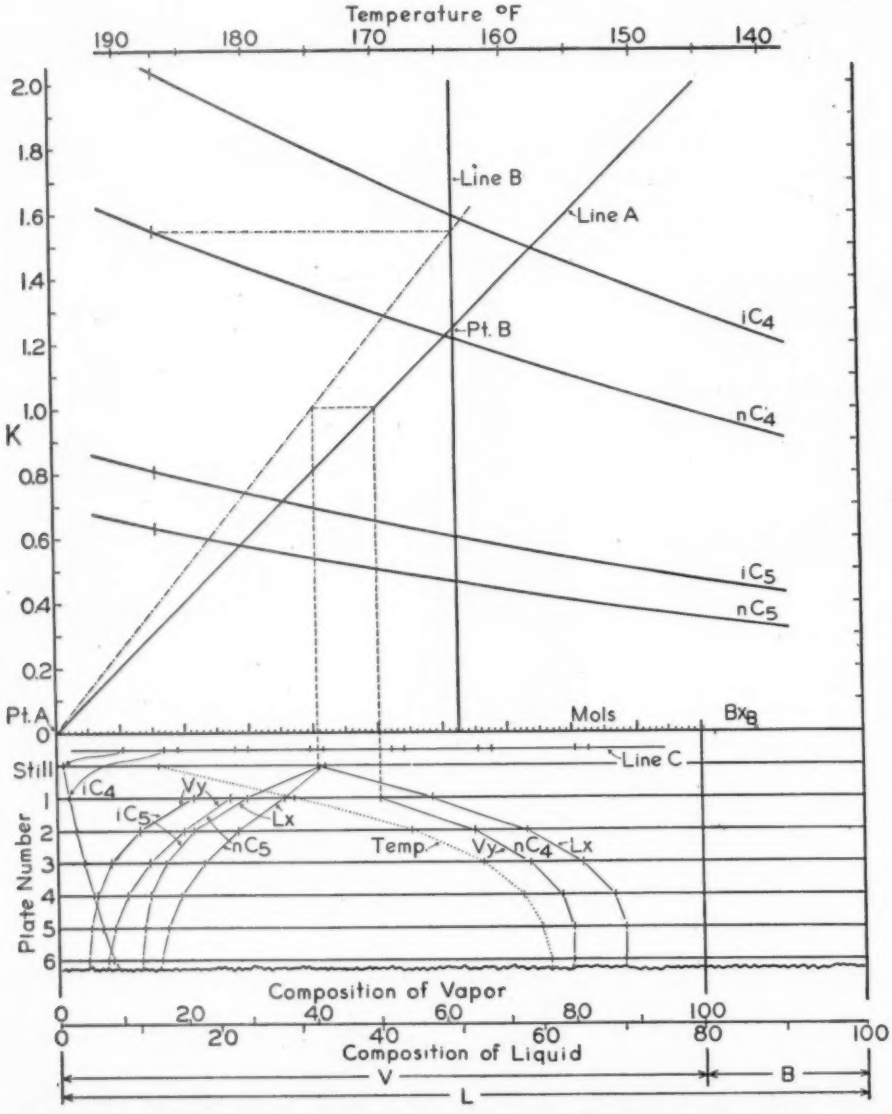
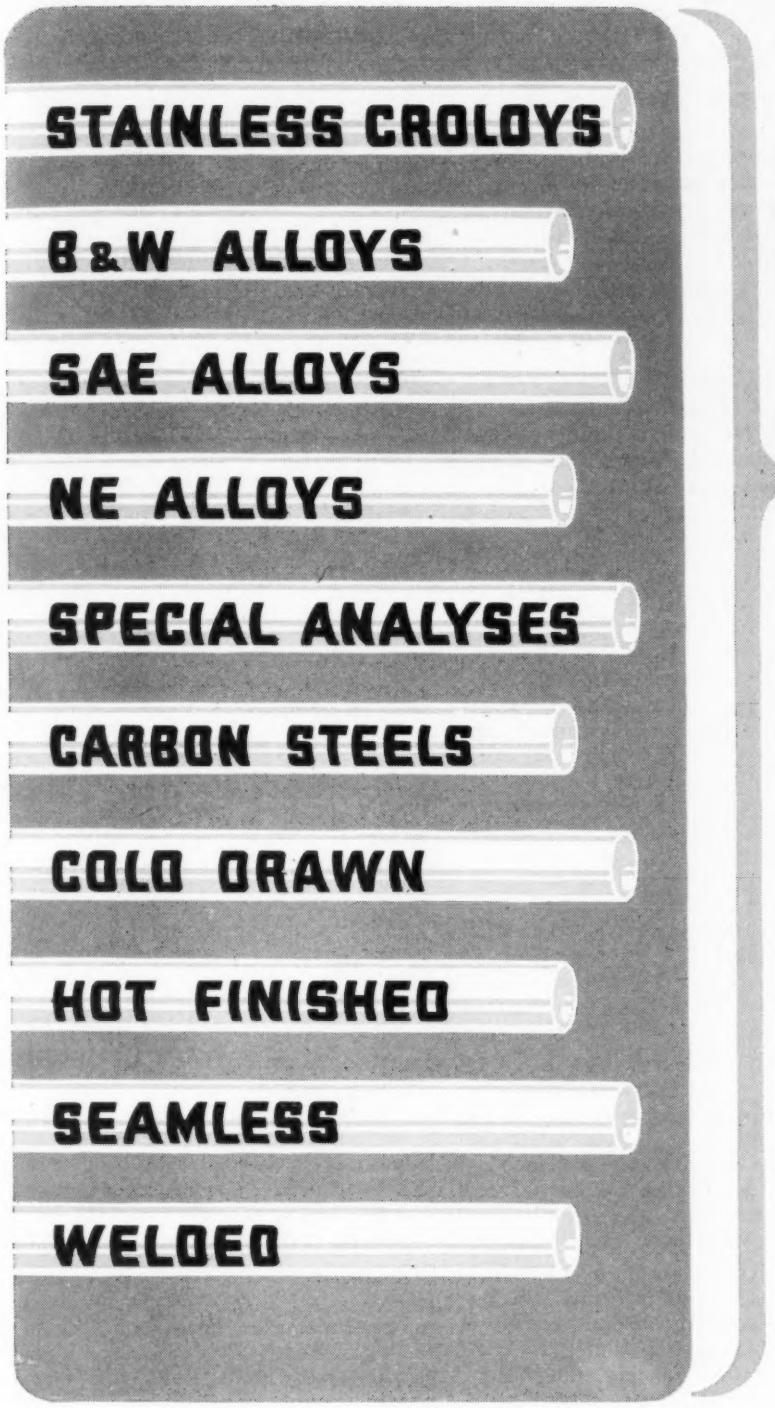


Fig. 2—Graphical arrangement for calculating plate-to-plate up the column from the still for the conditions of the example. See text for construction and procedure



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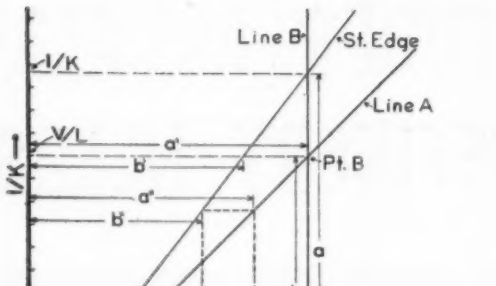

Fig. 3 (Left) — Construction used to prove that the graphical procedure described in Step 2 corresponds to the multiplication of Equation 2. See text

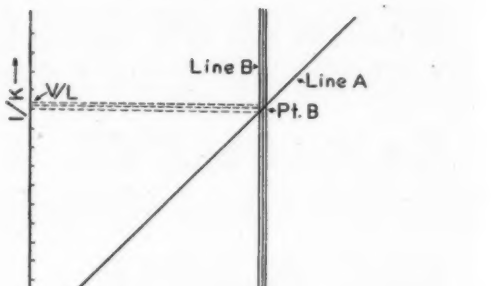

Fig. 4 (Right)—Construction for changing plate L and V values for above the feed. See text

The calculation is repeated on down the column, plate-by-plate, by the alternate repetition of the above steps. The values obtained for the top six plates are shown in Fig. 1.

Calculations for Bottom Plates

The graphical procedure for going up the column from the still is similar to the above and is illustrated on Fig. 2. The starting point for the calculations is given under "Conditions for Example," and these values of $L'x$ are marked off on the still composition line. For convenience, values of Bx_n for the components are marked off at the right end of the composition axis.

The first step, corresponding to Step 2 above, is to find the values of $V'y$ for the vapor to the bottom plate in equilibrium with the still liquid. Values of $L'x$ are multiplied by $V'K/L'$s to give values of $V'y$ (Equation 2). A temperature for the equilibrium is estimated and for one component the straightedge rotating through Point A is set on the point on Line B at the value of K for the component. This is shown for n-butane by the dot-dash lines of Fig. 2. Then from the value of $L'x$ in the still liquid go up to the straightedge, across to Line A, and down to the composition line for Plate 1. The result is a value for $V'y$ for the component in the vapor from the still. This step is shown for n-butane by the dashed lines of Fig. 2. Values of $V'y$ are determined similarly for the other components, and these are summed with calipers to give a calculated value of V'. If the original and calculated V''s differ too much, a new temperature is assumed and the calculation repeated. If they are sufficiently close then the individual values of $V'y$ are simply adjusted proportionally so as to total the desired V'. The result of this step is the mols of the components in the vapor from the still, and these values of $V'y$ are marked off on the composition line for Plate 1.

The next step, corresponding to Step 1 for above the feed, is to obtain values of $L'x$ for the liquid overflow from the bottom plate by means of Equation 4. Values of Bx_n for the components, as marked off at the right end of the composition axis, are added to the values of $V'y$ obtained above by means of a pair of calipers. This gives values of $L'x$ for the liquid to the still from the bottom plate. The result of this step, then, is a known liquid stream, and this was the starting point of the previous step. These two operations are repeated alternately up the plates of the column until a feed plate composition is reached. The first six of these plates are shown on Fig. 2.

Two special features of Figs. 1 and 2 will be noted. The first of these is the dotted line plot of temperatures vs. plate numbers. This curve is very useful in predicting the succeeding plate temperatures as the line is simply extended to give the assumed temperature for the next plate.

After the plate has been calculated the correct temperature is plotted and the line is again extended for the next plate. With this arrangement and after the first two or three plates the succeeding plate temperatures can be accurately predicted. As a result, a repetition of a plate calculation because of an error in the assumed temperature is very seldom necessary.

The second feature of the Figures is Line C. These lines are 10 to 1 enlargements of the scale of mols for the cut components at low concentrations and are for the purpose of increasing the accuracy. Thus on Fig. 1 the values of Lx and of Vy for the small concentrations of n-butane are marked off on Line C. The addition of Step 1 and the multiplication of Equation 2 in Step 2 are performed for n-butane with the 10 to 1 mol scale of this line. Values of Lx used in the summations to give total L in Step 2 are transferred to the plate composition line at the regular scale as shown. Line C of Fig. 2 is a corresponding 10 to 1 enlargement for the mols of iso-butane for the bottom few plates. The use of this type of scale enlargement permits greater accuracy with little inconvenience.

Discussion

One advantage of the graphical method given is the speed and convenience with which the plate-to-plate calculations can be performed once the procedure has become a habit. The revolving straightedge, calipers and a pencil are all of the tools that are needed. No numbers are written down and a slide rule is not used. No readings of K values as decimals are required. To set the straightedge through Point A and "run" the multiplication of Equation 2 requires but a few seconds. And the resultant values of Lx can be quickly summed with the calipers to give a value of L. The values of Lx can be adjusted proportionally "by eye" to give the desired total L. The whole operation can be performed with a speed that the equivalent algebraic procedure cannot match.

A second important advantage of the method is the ease of visualization that results from the graphical form. The entire calculation is on a single graph and can be seen at a glance. The final figure gives a complete picture of the conditions of the tower. During the calculation the effects of the variables can be better judged because the rates of change can be seen. The approach to the desired feed plate composition can be followed more easily. In addition, mistakes or errors of any size cause dislocations or "breaks" in the curves and so can be quickly spotted.

It is easy to show that the graphical procedures described give the desired mathematical operations. The additions of mols as lengths with calipers are obvious. Proof of the procedure described in Step 2 for multiplying Vy by VK/L to give Lx (Equation 2) is given on Fig. 3. By similar triangles $a/a' = b/b'$, or $a/b = a/b'$, and $a'/b' = a''/b''$. But $a = 1/K$ and $b = V/L$ so that $a/b = (1/K)/(V/L) = L/VK$. Also $a'' = Lx$ and $b'' = Vy$ so that $a''/b'' = (Lx)/(Vy)$. Then $a/b = a''/b'' = L/VK = (Lx)/(Vy)$,

or $Lx = (L/VK)Vy$. This, of course, is Equation 2.

Changing from one value of L/V to another as the calculation progresses is quite simple. The method of doing this for above the feed inlet is illustrated on Fig. 4. Two construction changes are necessary as shown. First, Point B and Line B are moved to the new value of $1/K = V/L$ on Line A. Second, the new values of L and V are marked off on the plate composition lines. For below the feed inlet the corresponding changes are: first, Point B and Line B are moved to the new value of $K = L'/V'$ on Line A; second, the new values of L' and V' are marked off on the plate composition lines. In this manner values of L and V may be changed at any plate as desired with little additional trouble.

In the actual calculations, of course, the dot-dash and dashed lines of the figure are not drawn but are simply followed with the eyes. To aid in this and to avoid eye strain it is better to have the lines of the paper strongly marked and with fairly large subdivisions. A ten-to-the-inch paper with the inch and half inch lines marked in different colors is satisfactory.

The final answer obtained for the conditions of the example is 20 plates above the feed inlet and 22 below for a total of 42 plates and the still. The ratio of n-butane to iso-butane in the feed plate liquid is 1.35, and this gives the minimum number of plates. These values do not take into account the effect of propane below the feed nor of the pentanes above the feed. These effects will increase the numbers of plates given above by fractions of a plate.

Nomenclature

B=Bottoms product. Mols per unit time.
D=Overhead distillate product. Mols per unit time.
K=Vapor-liquid equilibrium constant. $y=Kx$.
L=Liquid overflow from plates above feed. Mols per unit time.
L'=Liquid overflow from plates below feed. Mols per unit time.
m=Plate number below feed. Plate $(m+1)$ is directly above Plate m.
n=Plate number above feed. Plate $(n+1)$ is directly below Plate n.
V=Vapor rising to plates above feed. Mols per unit time.
V'=Vapor rising to plates below feed. Mols per unit time.
x=Mol fraction of component in liquid.
y=Mol fraction of component in vapor.
Stream numbering—The liquid stream to a plate and the vapor stream from it are subscripted with the [illegible] stream to the top plate, and L'_m is the liquid stream from Plate m. C and S refer to condenser and still.

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(4) Robinson and Gilliland, "Elements of Fractional Distillation", 3rd Edition, McGraw-Hill.
(5) Sorel, "Distillation et Rectification Industrielles", 1899.
(6) Underwood, Trans. Inst. Chem. Eng., 10, 131 (1932).

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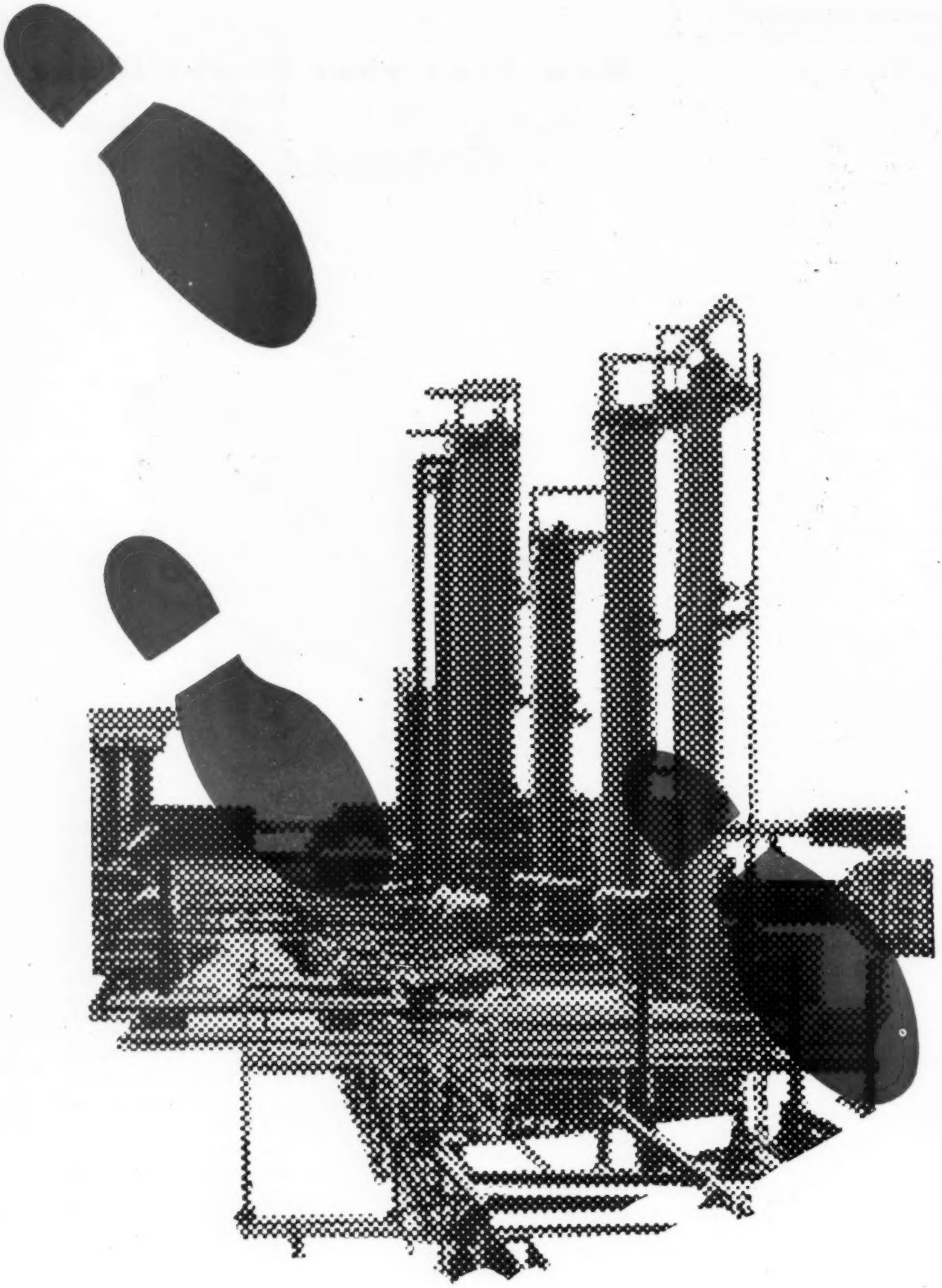

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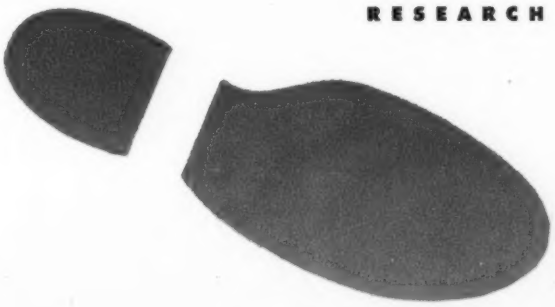

Patent Trends in Petroleum Refining

By Peter J. Gaylor

Patent Attorney and Editor "The Technical Survey"

Developments disclosed in the patents reviewed below include:

Process for producing triptane by demethylation of an isooctane

Better ductility and impact resistance in new asphalt blends

Viscosity index improvers for butadiene rubber copolymers

UOP Process for Triptane by Demethylation of Isooctane

IN HIS paper on "More Efficient Utilization of Fuels"*, Kettering has adequately shown that, of all of the less volatile, acceptable fuels, *triptane* has the highest antiknock properties, so it can be expected that more and more research work will be directed toward the synthesis of this important engine fuel ingredient from petroleum hydrocarbons.

A number of patents have been issued recently to Universal Oil Products Company, describing a process of *demethylation* of an isooctane, 2,2,3 trimethylpentane, which is present in minor amounts in hydrodimers, hydrocodimers, and alkylates.

In its U. S. Patent 2,422,672, a butene hydrocodimer fraction boiling at 194° F. and over, and containing 2,2,4-, 2,2,3-, 2,3,4-, and 2,3,3-trimethylpentanes and higher hydrocarbons, is fed into fractionator 3 through line 1 of Fig. 1. A fraction boiling between 194°-239° F. is taken overhead through line 7, and is composed of the various trimethylpentanes. This fraction is then fed to fractionator 22, wherein a cut boiling between 194°-226° F. is removed through line 24, the components being mainly 2,2,4 trimethyl pentane and 2,3 dimethyl pentane. The bottoms leaving line 39 consist mainly of 2,2,3-, 2,3,4- and 2,3,3,-trimethylpentanes. These are heated in furnace 43 to 400°-650° F. at about 510 psi, and mixed with hydrogen in mixing chamber 46, the separately heated hydrogen coming from line 47 and furnace 50.

The mixed vapors are then fed into reactor 61 containing a suitable hydrogenating catalyst, such as 66% total nickel, 30% diatomaceous earth, and 4% oxygen as nickel oxide. The reactor is insulated and is heated with tubes through which is circulated Dowtherm at 12-14 psia, with temperature of 480-490° F. It is important to keep close control of the temperature in this unit.

The dimethylation reaction is highly exothermic and usually liberates enough heat to maintain the heat exchange medium at the desired temperature, but provision is made to supply additional heat, if needed, through the means of furnace 81. The temperature of the demethylation is closely related to the pressure, and since the hydrogen is consumed in the lower portion of the reaction zone, there is a decrease in available hydrogen and a corresponding reduction in pressure in the upper portion of the reaction zone. One suitable means for accomplishing a 10°-20° F. differential in reactor 61 is by maintaining a level of liquid in drum 62. Levels 85 and 85' would then be about the same as the catalyst level in the tubes of reactor 61, and the pressures at the lower portion of the surrounding space and drum will be higher due to the fluid head of liquids therein. The vapors are then condensed in condenser 88 and led into successive flash zones 91 and 92 for decreasing pressure, with hydrogen leaving through line 93.

In a process such as that described, it is claimed that there may be produced, based upon an isooctane fraction charge of 1257 gals./day, the following products:

	Gals./day
Higher boiling isooctane bottoms	251
2,2,4-trimethyl pentane and 2-3-dimethyl pentane fractions	662
2,2- and 2,3-dimethyl butane fraction	77
Triptane (2,2,3-trimethyl butane) fraction	193
Total	1183

The desired reaction is a clean splitting of the methyl group which, in presence of hydrogen, comes off as methane:

In U. S. Patent 2,422,674, the same firm discusses the chemistry involved, the catalysts, and the effect of reactor conditions on the yield of triptane. When producing triptane by demethylating 2,2,3-trimethylpentane, it is necessary to correlate properly operating pressure, catalyst activity, and partial pressure of hydrogen, or no triptane will be produced. If the temperature is too low, the feed will pass through the reactor unchanged, while if it is too high, it may be converted mainly to methane by suc-

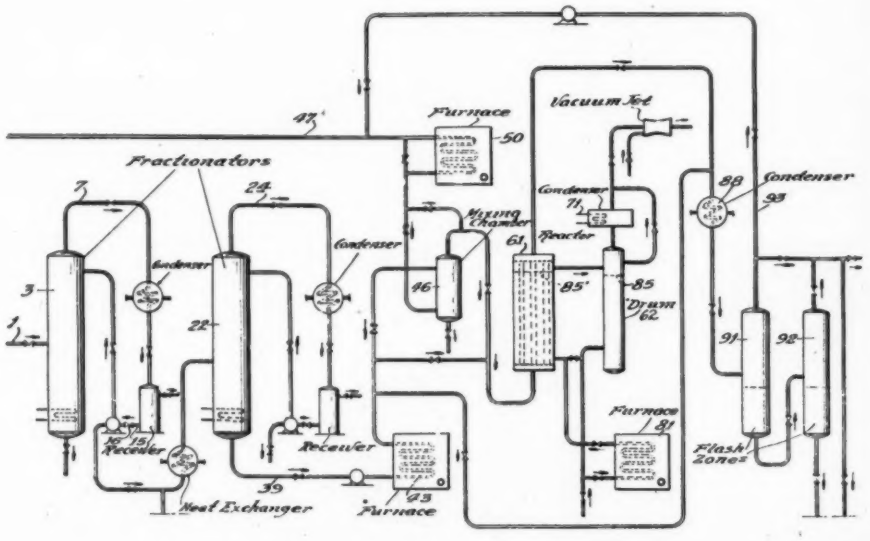

Fig. 1—Flow diagram for Universal Oil Products' process of demethylation of 2.2.3 trimethylpentane to produce triptane

* PETROLEUM PROCESSING, pg. 487, July, 1947.

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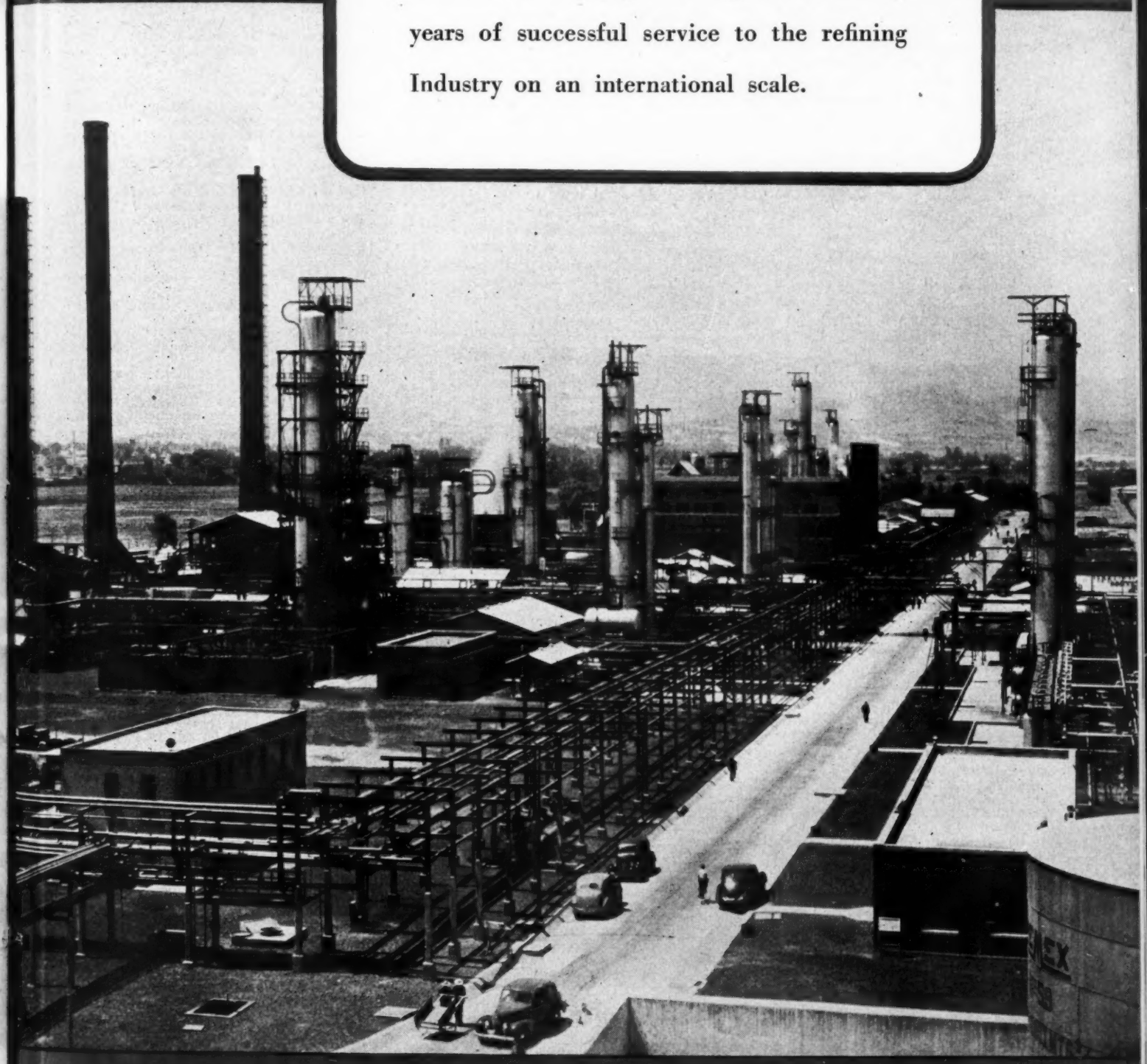

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cessive demethanation. Increase in pressure and hydrogen partial pressure must be accompanied by an increase in catalyst temperature in order to maintain a given conversion of feed to heptanes and other demethylated hydrocarbons.

The process is also applicable to other hydrocarbons, such as the straight chain paraffins. For example, demethylation of n-hexadecane (cetane), using nickel catalyst pretreated with hydrogen at 1000° F., and running at 490°-600° F., with pressures up to 200 psi and hydrogen: hydrocarbon ratios of 4:1-8:1; a 44.4% conversion to lower hydrocarbons was obtained, the composition of the products being as follows:

Compound	Mole Per Cent
n-$C_{15}H_{32}$	29.8
n-$C_{14}H_{30}$	20.4
n-$C_{13}H_{28}$	13.5
n-$C_{12}H_{26}$	9.8
n-$C_{11}H_{24}$	6.2
n-$C_{10}H_{22}$	5.8
n-C_9H_{20}	4.9
n-C_6H_{18}	4.7
n-C_7H_{16}	2.7
n-C_6H_{14}	2.2
Total	100.0

Better Impact Resistance For New Asphalt Blends

BITUMINOUS compositions of improved ductility, pliability and impact resistance are possible by the blending of asphalt with oil-soluble acrylate or methacrylate polymers. According to Standard Oil Development Company's patent 2,420,082, only small quantities of these polymers are said to be needed to produce noticeable improvement in quality. Usually 2-5% is sufficient.

Tables 2 and 3 show inspection data on asphalts blended with n-decyl acrylate and octyl methacrylate polymers. Improvement can be noted in pliability, ductility, softening point, etc.

TABLE 2—Inspection Data on Asphalt Blended with N-Decyl Acrylate

	Example 1		Example 2	
Per cent Asphalt	100	95	100	95
N-Decyl acrylate	0	5	0	5
Softening Point, ° F. (B&R)	171	163	231	237
Penetration at 77° F.	31	85	16	48
Penetration at 32° F.	21	65	12	38
Ductility at 77° F. (cm.)	4	100+	2½	19
Pliability at 20° F. (degrees), Reeve and Yeager	9	180+	10	180+
Impact at 20° F. (inches)	1½	15	2	19+
Ratio of Pen. 77°F./100 g./5" / Pen. 32°F./200 g./60"	1.5	1.3	1.3	1.3

TABLE 3—Inspection Data on Asphalt Blended with Methacrylate Polymers.

Polymer Concentration of Octyl Methacrylate	...	2	5	...	...	Typical
Polymer Conc. of Decyl-Methacrylate	...	...	...	2	5	Colombian
Colombian 180/200° St. O. Asphalt, Per cent	100	98	95	98	95	Coating.
Softening Point, °F.	197	206	233	199	217	231
Penetration at 77° F.	22	19	21	20	24	16
Penetration at 32° F.	17	16	17	16	20	12
Barber Stain	...	3	3	3	3½	4

Viscosity Index Improvers Of Butadiene Rubber Copolymer

THE preparation of a new class of viscosity index improvers has been disclosed in the Socony-Vacuum Oil Co. patent 2,399,817. Rubbery copolymers of butadiene with unsaturated ketones such as naphthenyl ketone and oleyl ketone are employed. These polymers are oil soluble and have molecular weights between 840-1650.

Their effectiveness has been demonstrated by obtaining kinematic viscosities of blends in mineral lubricating oils, one series of tests showing the results given in Table 4.

TABLE 4—Effectiveness of New Type Viscosity Index Improvers

	Conc. thickener % by wt.	Kinematic viscosity 100°F.	210°F.	V.I.
Oil	0	29.56	4.72	76.7
Oil + copolymer of oleyl ketone	2	35.25	5.61	106.9
Oil + copolymer of oleyl ketone	1	32.51	5.16	94.4
Oil + copolymer of oleyl ketone	0.5	31.22	4.98	88.8

Selected Patents of the Month

U.S. 2,420,418 (Mid-Continent Petr.)—Dewaxing.
U.S. 2,420,446 (Gulf Res. & Dev.)—Lubricating oil containing halogenation retardant.
U.S. 2,420,558 (Standard Oil Development)—Catalytic conversion.
U.S. 2,420,563 (I.C.I.)—Hydrocarbon dehydrogenation catalyst.
U.S. 2,420,632 (Standard Oil Development)—Regenerating cracking catalyst.
U.S. 2,420,834 (Shell Dev.) — Cyclic monosulfones.
U.S. 2,420,893 & 902 (Standard Oil Development)—Compounded lube oil.
U.S. 2,420,938 (Union Oil)—Nitric acid as selective solvent in oxidation of naphthenes.
U.S. 2,420,953 (Standard Oil—Indiana) — Hydrocarbon oil resistant to copper plating.
U.S. 2,420,954 (Danciger Oil & Refineries) — Electrolytic production of succinic acid from butyrolactone.
U.S. 2,421,004 (Socony Vacuum)—Detergentized oil.
U.S. 2,421,030-1 (Phillips Petr.)—Amides and thioamides.
U.S. 2,421,040 (Alox Corp.)—Polar type corrosion inhibitors.
U.S. 2,421,212 (Shell Dev.)—Operation of fluidized systems.
U.S. 2,421,223 (Gulf Oil) — Stabilized pyrethrum.
U.S. 2,421,229 (Univ. Oil Products)—Separating isobutene.
U.S. 2,421,392 (Shell Dev. Co.)—Sensitization of HBr catalyzed oxidation reactions.
U.S. 2,421,421 (Lion Oil)—Oxidizing high molecular weight hydrocarbons in presence of halide.
U.S. 2,421,422 (Socony)—Interpolymerization of isobutene and isopentenes with H_2SO_4.
U.S. 2,421,507 (Shell Dev.) — Horticultural spray oil.
U.S. 2,421,524 (Shell Dev.) — Purification of metal halide catalyst.
U.S. 2,421,543 (Union Oil)—Lubricant containing dispersed metal sulfide.
U.S. 2,421,545 (Phillips Petr.)—Mercaptan oxidation process.
U.S. 2,421,554 (Shell Dev.)—Catalytic cleavage of glycols.
U.S. 2,421,608 (Standard Oil Dev.)—Aromatic amines from nitro compounds.
U.S. 2,421,619 (Anglo-Iranian)—Motor or aviation fuels.
U.S. 2,421,672 (Union Oil)—Rust preventive composition.
U.S. 2,421,674 (Pure Oil)—Isoparaffins and catalyst reactivation.
U.S. 2,421,677 (Kellogg)—Cyclizing hydrocarbons to aromatics.
U.S. 2,421,862 (Standard Oil Development)—Polyhydric alcohols by reacting cyclic formals with alcohols.
U.S. 2,421,937 and 1,031 (Shell Development)—Imines.
U.S. 2,421,946 and 50-1 (Universal Oil Prods.)—Polymerizing olefins with BF_3 and fluorosulfonic acid, etc.
U.S. 2,422,075 (Texas Co.)—Stabilized lubricating emulsions.
U.S. 2,422,206 (Standard Oil Ohio)—P-S lubricant.
U.S. 2,422,233 (Standard Oil Development)—Isomerization.
U.S. 2,422,341 (Phillips Petroleum) — Solvent extraction with a liquid alkyl mercapted.
U.S. 2,422,346 (Socony)—Isomerization.
U.S. 2,422,349 (Phillips Petroleum)—Alkylation
U.S. 2,422,372 (Shell Dev.)—Alumina supported Mo oxide catalyst.
U.S. 2,422,373 (Gulf Oil)—Rotary filter.
U.S. 2,422,435 (Universal Oil Products)—Cyclohexene oxides.
U.S. 2,422,468 (Standard Oil Development)—Electrolytic production of pinacols.
U.S. 2,422,484 and 503 (Standard Oil Development)—Stabilized xylidine.
U.S. 2,422,485 (Standard Oil Development)—Xylidine and toluene production.
U.S. 2,422,499 (Standard Oil Development)—Spherical alumina gel.
U.S. 2,422,501 (Standard Oil Development)—Carrying out chemical reactions.
U.S. 2,422,515 (Standard Oil Ind.)—Amides for preventing corrosion of pipe carrying oils.
U.S. 2,422,566 (Standard Oil Ind.)—Non-clogging fuel oil.
U.S. 2,422,648 (Shell Dev.)—Dihydropyran.
U.S. 2,423,493-4 (Pure Oil)—Hydrocarbon conversion in presence of sensitizers.
U.S. 2,423,530 (Pure Oil)—Alkylation of aryl hydrocarbons.
U.S. 2,423,612 (General Motors) — Isomerizing olefins.
U.S. 2,423,674 (A. Johnson & Co.)—Catalytic cracking in shale bed.
Can. 440,874 (Calif. Res. Corp.)—Detergentized lubricating oil.
Austral. Appl. 9493/47 (Gulf Res. & Dev.) — Preventing foaming of oils.
Austral. Appl. 9136/47 (Hydrocarbon Research)—Gasoline hydrocarbons.
Austral. Appl. 9245/47 (Shell)—Combating insects' noxious organisms.
Austral. Appl. 10752-5/47 (Davison Chem. Corp.)—Magnesia silica catalysts and gasoline production.
Austral. Appl. 10776/47 (Shell)—Lithium soap greases.
Austral. S.P. 119,561 (Steinschlaeger)—Synthetic hydrocarbon oils.

Heat Waste and Vapor Loss Reduced By Baffles Inside Catalyst Stripper

In addition to the improved catalyst stripper described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have recently been issued includes:

- **Hollow stud arrangement simplifies plug valve repacking.**
- **Slip-type joint can be cooled for high temperature service.**
- **"Smear-wash" technique improves filtrate recovery.**
- **Need for template eliminated by method for welding pipe.**
- **Installation is inexpensive for new bubble tray risers.**

HEAT WASTE and hydrocarbon loss can be reduced, and the efficiency of the stripping step in Fluid catalytic cracking units increased to 95-100%, with an improved stripper incorporating an arrangement of baffles, it is stated.

In modern cat crackers spent catalyst is withdrawn from the bottom of the reaction vessel in a relatively dense, dry, fluidized, liquid-simulating condition, causing incomplete stripping with conventional equipment. This is because of the increased adsorption of hydrocarbon liquids and vapors on the catalyst particles and the increased entrainment. The result is higher loss of feed stock as coke is burned off in the regenerator. In addition, more heat is produced than is required in the process.

In older catalytic units, vapors and particles are passed overhead in relatively dilute suspension, and stripping is not a troublesome problem, it is claimed.

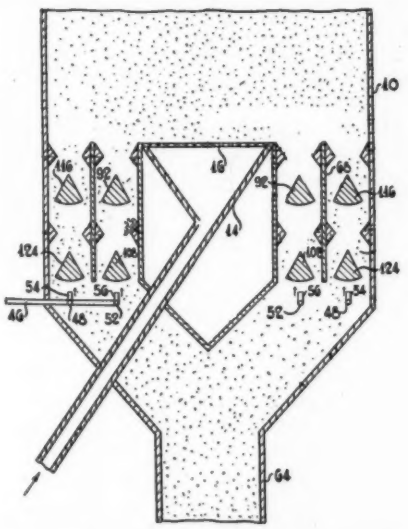


Fig. 1—Cross-section of improved catalyst stripper (U. S. 2,422,262) showing arrangement of baffles which increases the stripping efficiency

The improved stripping section design is shown in cross-section in Fig. 1. Reactor vapor-catalyst mixture passes through inlet line 12 to cone 14 in the center of cylindrical stripper 10, and thence upward through grill 16. A conventional cyclone or other type separator in the top of the stripper releases hydrocarbon vapors to the next step in the process.

Spent catalyst flows down through standpipe 64 to the regenerator. Stripping gas—superheated steam, inert gases, or recycle gas—is admitted through line 46 to circular pipes 48 and 52 each equipped with feed nozzles 54 and 56.

The high turbulence and reduced cross-sectional area desired for increased stripper efficiency is obtained by means of the disc-and-doughnut type construction of annular baffles 68, 92, 108, 116, and 124. A modified form of the design provides for passing stripping gas transverse to the flow of catalyst as well as countercurrent, and is said to further increase the stripping efficiency.

U. S. 2,422,262, issued June 17, 1947, to Barrett B. Russel, 3rd, assignor to Standard Oil Development Co.

Plug Valve Repacking Simplified With Hollow Stud Arrangement

EXTRA FITTINGS are not needed in the body of a new plug valve which can be repacked during normal operating conditions without being taken apart. Means are also provided for a tight seal in the open position of the plug, as well as a release without leakage when the plug is rotated.

The valve is shown in the cut-away, perspective view in Fig. 2. Plug channels 30 and 31 receive packing material, preferably grease, through port 32. An ordinary grease gun can be attached to the standard grease gun fitting 35 on the upper end of the hollow stud bolt 21, which carries packing to port 32. Check valve 34 holds grease in place.

Machined surfaces 81 (on the plug) and 80 (on cap 15) provide a tight seal when follower 28 is removed for repacking gland space 26. Thus, it can be seen that the valve stem can be repacked during normal operations without dissembly.

Rotation of the plug is effected by head 40, keyed to valve stem flat-sided section 41. A limited reciprocal motion of the plug to release it for rotation, is provided by actuating member 52 through its threaded engagement with plate 51, a part of cap 15.

U. S. 2,421,879, issued June 10, 1947, to Leland S. Hamer, Long Beach, Calif.

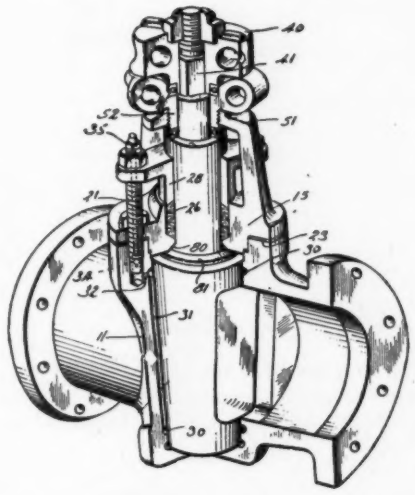


Fig. 2—Cutaway view of improved plug valve (U. S. 2,421,879). Packing grease enters through fitting 35 at end of hollow stud 21

Slip-Type Joint Can Be Cooled For High Temperature Service

SAID TO BE particularly advantageous for use in cracking units where temperature ranges reach as high as 1400° F., a slip-type expansion joint includes provisions for cooling, thus minimizing strains due to high temperatures and possible damage to gasket materials.

Shown in Fig. 3, the joint consists of an inner tube 1 sliding within the casing 2. Within the annular chamber 5 formed by the two tubes is a lantern ring 7 of open web construction 8. This ring has flanged end of about 1/16 in. general clearance from tubes 1 and 2.

Packing material such as asbestos, fills the space beyond each end of the ring 7, and is compressed into place by ring 9 and bolts 10 connected to flange 11 on casing 2. A cooling medium, such as steam, is admitted through line 17;

the exit on the opposite side of the joint is not shown.

U. S. 2,422,502, issued June 17, 1947, to Leo W. Schrader, assignor to Standard Oil Development Co.

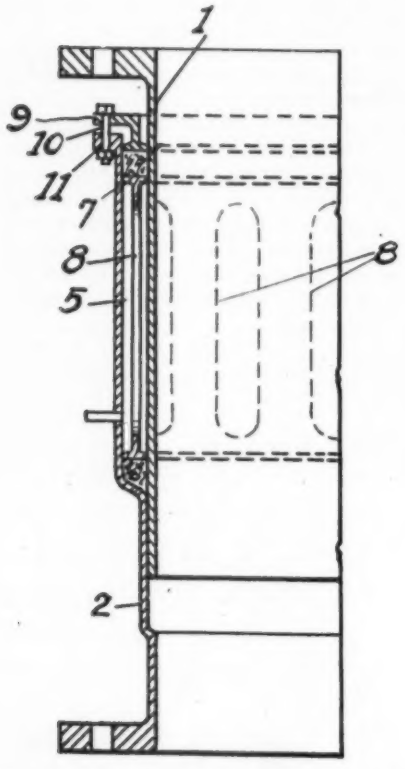


Fig. 3—Cooling fluid for high-temperature, slip-type, expansion joint (U. S. 2,422,502) enters annular chamber 5 through line 17

Filtrate Recovery Is Improved Using "Smear-Wash" Technique

MORE EFFECTIVE recovery of filtrate in a rotary precoat filter is claimed to result from use of a so-called "smear-wash" attachment.

Advantage is said to be that valuable filtrate ordinarily retained on the surface of the filter-aid as soakage, is replaced by low-cost wash liquid. The loss of filterable liquid in shaving the precoat is thus minimized.

A cross section of a typical rotary precoat filter with the smear-wash device is shown in Fig. 4. Cylindrical shell with open segment is indicated generally by 10. Mixture of liquid to be filtered and a filter-aid material is fed into shell 10. Filter cylinder 11 rotates counter-clockwise. Vacuum inside cylinder 11 draws filtrate through coat of filter-aid which builds up as at 12. As impurities collect on coat 12, they are shaved off by the rotation of cylinder 11 past knife-edge 21.

Washing liquid passes in through pipe 34 and is distributed across the top of surface 12 by means of openings 35 in line 34, and distribution tray 39. (See Fig. 5). The outer edge 41 of tray 39 is a serrated strip. Saw-teeth notches permit wash liquid to flow evenly reaching all points on the surface of the precoat evenly and avoiding channeling effects.

U. S. 2,422,373, issued June 17, 1947, to Herschel G. Smith, assignor to Gulf Oil Corp.

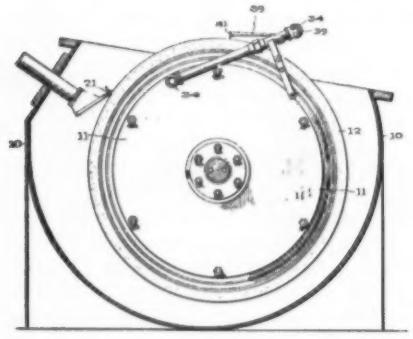


Fig. 4—Cross-sectional view of rotary precoat filter using "smear-wash" attachment (U. S. 2,422,373), mounted at top of equipment

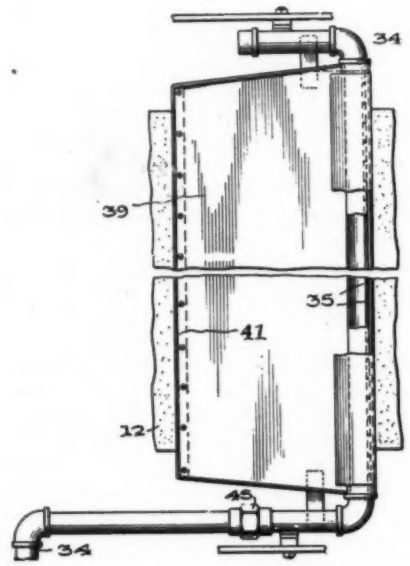


Fig. 5—Plan view of the smear-wash apparatus which distributes wash liquid evenly over the surface 12 of the precoat

Need for Template Eliminated By Method for Welding Pipe

WHEN PIPE is to be joined by welding and where the pipe axes are not at right angles, it has been found rather difficult to develop templates which will allow proper marking of the primary pipe. Ordinary right angle joints on the other hand are relatively simple to handle by means of a marking template.

A California inventor has patented a machine which permits acute angle pipe joints to be made and cuts primary pipe ends without the use of a template. Method is said to work equally well where the two pipes are of different diameters. Operation of the machine consists in contolling the movement of a cutting torch through a route of travel based on a mathematical formula which was derived from the angle of the pipe axes and the diameters of the two pipes.

Machine makes proper cut on end of primary pipe, which is then used as a template to mark the secondary pipe. Time is saved, it is claimed, by using short nipples as primary pipe, later welding on extensions to the desired lengths.

U. S. 2,422,338, issued June 17, 1947, to Edwin S. Christensen, Long Beach, California.

Installation Is Inexpensive For New Bubble Tray Risers

COMPARATIVELY INEXPENSIVE means for fastening risers in bubble-cap trays is claimed for an improved riser of cylindrical form with its lower end arranged to be expanded and secured in the floor of the tray, providing a fluid-tight seal.

As shown in Fig. 6, bubble tray floor 14 is provided with an opening 15 of such diameter that the marginal materials can be extruded upwardly forming a collar 16 in which the riser 10 will fit snugly.

The riser 10 is uniformly cylindrical in shape and is rolled from a strip of metal to leave a slight gap 11. A weld 12 is applied to the gap in part, leaving an expansible shirt 13. The riser is then driven into opening 15 of the bubble tray and expanded by any conventional method. It is tack welded at a few points around the circumference to assure rigid mounting. If it is necessary to replace the riser, the welds can be quickly melted and the riser driven downwardly and out of the floor.

U. S. 2,422,300, issued June 17,1947, to Hans C. Glitsch, assignor by mesne assignments to Glitsch Engineering Co., Dallas, Texas.

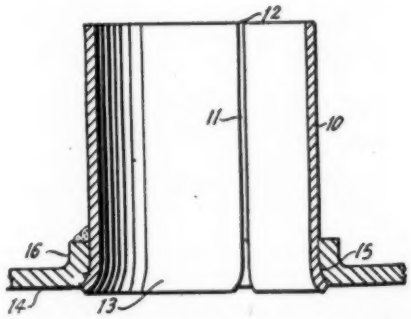


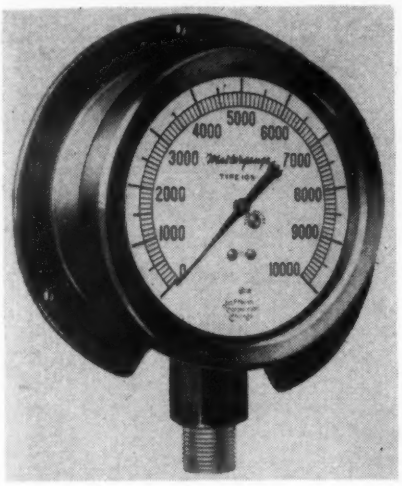
Fig. 6—Expansible skirt 13 on bubble-cap riser (U. S. 2,422,300) forms fluid-tight seal with the floor

What's New!

Edited by
WILLIAM C. UHL
Equipment Editor

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

1—Corrosion-resistant Gage



The Type 105 Mastergauge pressure gage for corrosion service is recommended for use with alcohol (ethyl, methyl, propyl), cold sulfuric acid, hydrogen sulfide, sodium chloride, milk of lime, carbon tetrachloride, and many others. Bourdon tube and locktite cones of beryllium copper. Bronze bushed movement with bronze pinion and arbor. Equipped with the Marsh "Recalibrator" for correction in case it is knocked out of adjustment through improper handling. Available in 4½ or 6 in. dial in cast iron or cast brass case, plain or flanged with screwed ring. Capacity ranges 0 to 6000 or 0 to 10,000 psi. Jas. P. Marsh Corp.

2—Impact Tool

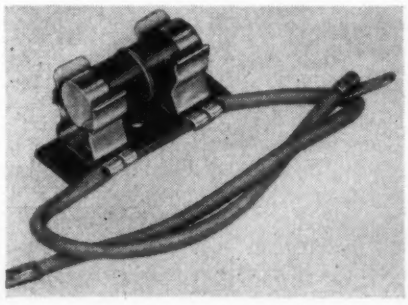
The new, electric, all-purpose, Impact Tool, Size 4U, operates just as any conventional electric tool until the resistance to spindle rotation reaches a certain amount, at which point the power of the motor is converted automatically to "rotary impacts". The spindle can be stalled completely while the motor continues to run, eliminating motor burnouts from overloading, it is said. Will apply and remove nuts, run wire brushes, drive and remove studs, drill brick and masonry, etc. Weight, 6½ lbs.; over-all length, 10½ in.; free speed, 2000 rpm.; delivers 1900 impacts per minute under load. Powered with reversible 3 amp. motor. Operates on 110 volt, AC or DC. Ingersoll-Rand Co.

3—Check Valve

Adapted for use with manufactured, natural, or liquefied petroleum gases, the new "3000" series of Swing Check Valves is said to offer the advantages of sensitivity to low flow, full flow with minimum resistance, non-leaking, and a free action mechanism which will not stick on minimum flow. Available in screwed and flanged types, in bronze aluminum and gray iron, in I.P.S. sizes from ½ to 6 in. Pokorney Manufacturing Co.

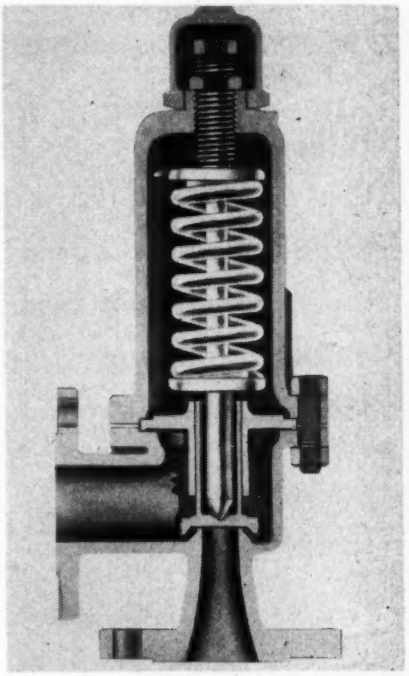
4—Mercury Switch

Especially adapted to explosion hazard areas, a line of 5, 10, 15, and 20-amp. mercury switches are said to provide mercury-to-mercury contact without arcing, pitting or burning. Will operate at 110 and 220 volts AC or DC, in an ambient temperature of 212° F. Hydrogen pressure inside switch to quench arc is 28 psig. Tests have shown switches capable of short time standing up under 400% overload. Size; 1½ in. long by ½ in. diameter. Also available in miniature unit; 1 in. by ½ in. Mercontrol, Inc.



5—Acid Service Valve

A new line of corrosion resistant safety and relief valves for acid service in the petroleum and process industries is said to reduce maintenance costs because all working parts are isolated behind a vapor-proof, flexible curtain attached to the disc at one end and the flanged disc guide at the other. Material of the seal may be rubber, Neoprene, or flexible metal of proper specifications. Available with flange connections in sizes ½ to 2 in.; with screwed connections in sizes from ½ to 1 in. Farris Engineering Corp.



6—Flow Template

The No. 42 Flow Template for gas, oil, water, and chemical pipe layouts, includes cut-outs covering all the symbols shown in the American Standards Manual Z32.2. Made of 0.040 mathematical quality plastic. Printing is laminated between sheets to prevent wearing off. Symbol cut-outs are beveled. Size 2¾ x 6¾ in. with rounded corners. Rapidesign, Inc.

For More Information

Use one of the attached business reply cards, which requires no postage, to request additional details or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail.

More "What's New!" Items on Page 627

Improve Your Gasoline Stability With 1 of These 3 DU PONT ANTIOXIDANTS

The addition of one of these three Du Pont Gasoline Antioxidants will protect your gasoline against oxidation during storage—will keep your motor or aviation fuels up to your refinery standards. Select the one best suited to your blend of gasoline.

No. 5 is normal-butyl-para-aminophenol (50% solution in solvent).

No. 6 is Iso-butyl-para-aminophenol (50% solution in solvent).

No. 22 is N:N′-disecondary-butyl-para-phenylene-diamine, (100% active ingredient).

Write for complete information
E. I. du Pont de Nemours & Co. (Inc.),
Petroleum Chemicals Division,
Wilmington 98, Delaware.

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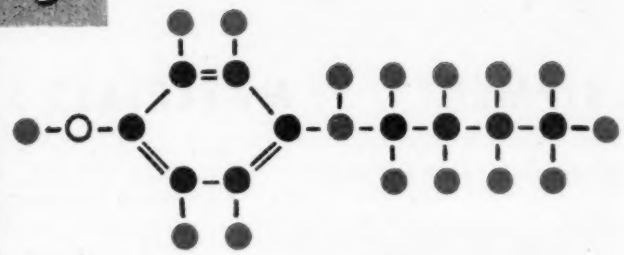

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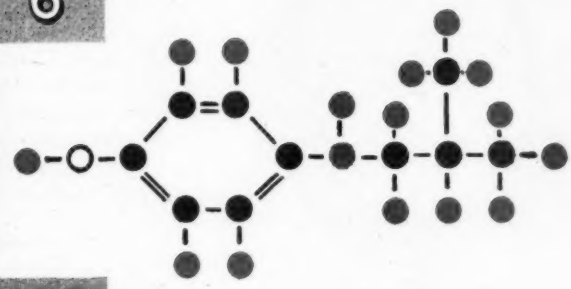

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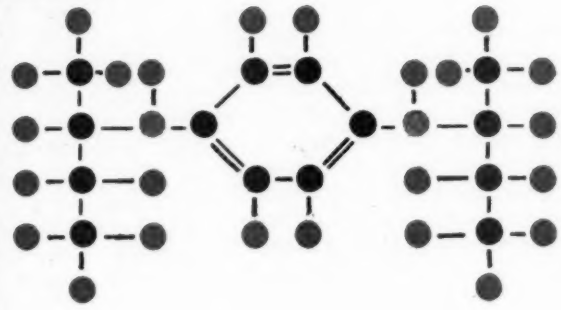

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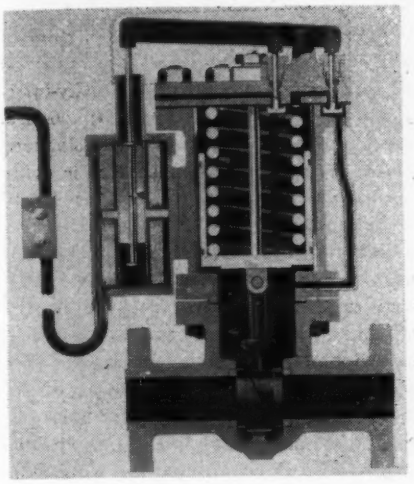
BETTER THINGS FOR BETTER LIVING . . .
THROUGH CHEMISTRY

7—Valve Control



Using line pressure to open and a compressed spring to close the valve, Shafer Electric Valve Controls can operate at any pre-determined speed at low or high temperature or pressure in air, water, oil, gas, or steam service. Current is used only in opening or closing, not for maintaining position. When used in gate valves, as shown in photograph, valve can be installed with either side to upstream pressure. Control is available for valves from 1 in. up, and for pressures ranging from 25 to 6000 psi. Applicable to gate, globe, angle, and other screw-operated valves. Operates on either 110 or 220 volt AC or DC. Shafer Valve Co., Inc.

8—Centrifugal Compressor

Model 18T300, a centrifugal compressor designed to use propane in a refrigeration cycle, is expected to find wide use in refineries because of small size, covering floor area 5 x 15 ft. First unit will be used by Atlantic Refining Co. in dewaxing at its Point Breeze, Pa., plant. Having five stages, it is a 2000 cfm compressor, operating between 21 psia inlet and minus 22° F, and discharging into a condenser at 195 psia. Requires 975 brake hp. at speed of about 9400 rpm. Other units in same line range in capacity from 1000 to 30,000 cfm. Inlet temperature ranges from minus 150 to 150 F. Inlet pressure ranges from high vacuum to 200 psi. Carrier Corp.

9—Plastic Gasket

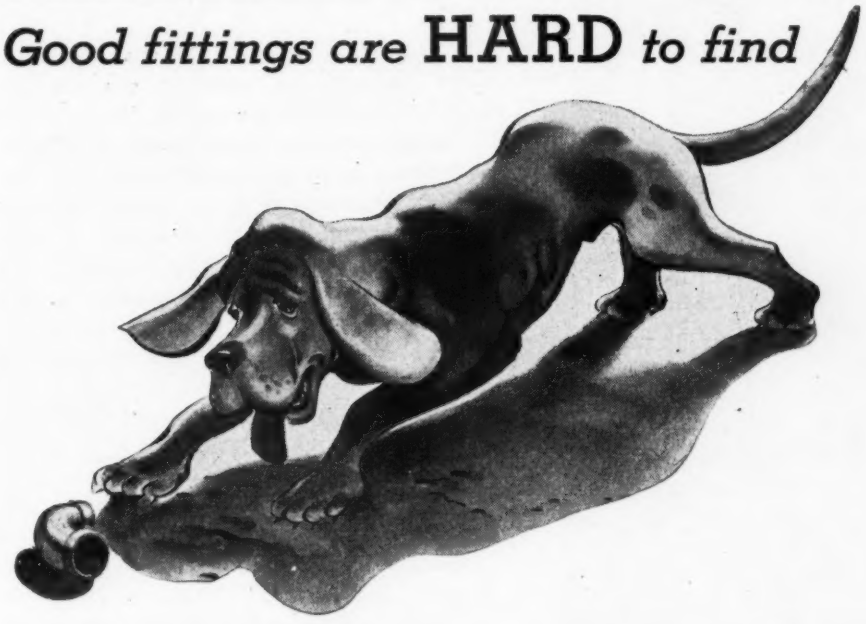
Under the trade name "Chemiseal," gaskets made of Teflon (polytetrafluorethylene) have been successfully produced by a technique imparting resiliency characteristics to the plastic. Teflon has been demonstrated to be fully resistant to all chemical materials except molten sodium, and fluorine under pressure. Gaskets will withstand −200° to +500° F. without embrittlement or decomposition, will not stick to flanges, or become coated with process materials. Standards have been set up for use in equipment manufactured by Glascote, Pfaudler, Haveg, Corning, Karbate, and special applications can be designed on request. United States Gasket Co.

10—Darkroom Sink

A new portable sink for the photographic laboratory is made of black thermosetting plastic, and is immune to attack by chemicals usually encountered in darkroom work. Size: 36 in. long, 18 in. wide, 6 in. high, 4½ in. deep inside. Will accommodate all film processing, including color, up to 4 x 5, and prints up to 8 x 10. Features include non-clogging syphon drain to maintain correct level of running water, and stainless steel trim. Ingraham-Fisher.

More "What's New!" Items on Page 628

Good fittings are **HARD** *to find*

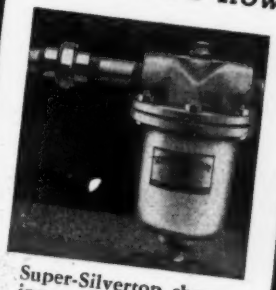


SAVE 7 PER TRAP WITH SUPER-SILVERTOP

When you see the meager results of a strenuous search for "hard-to-get" fittings, you'll want to make sure those fittings are not wasted. Trap your equipment with Super-Silvertops and you save as many as 9 fittings per trap installed. It's the built-in U-tube that makes such savings possible; and in Super-Silvertop there are no cored passages, no split gaskets to weaken the design. Find out all the facts about simplified piping with Super-Silvertop—fully described in the book "How To Choose A Steam Trap." Your free copy will be sent on request.

THE V.D. ANDERSON COMPANY
1974 W. 96th Street • Cleveland 2, Ohio

and here's how



Super-Silvertop showing one nipple and one union needed.

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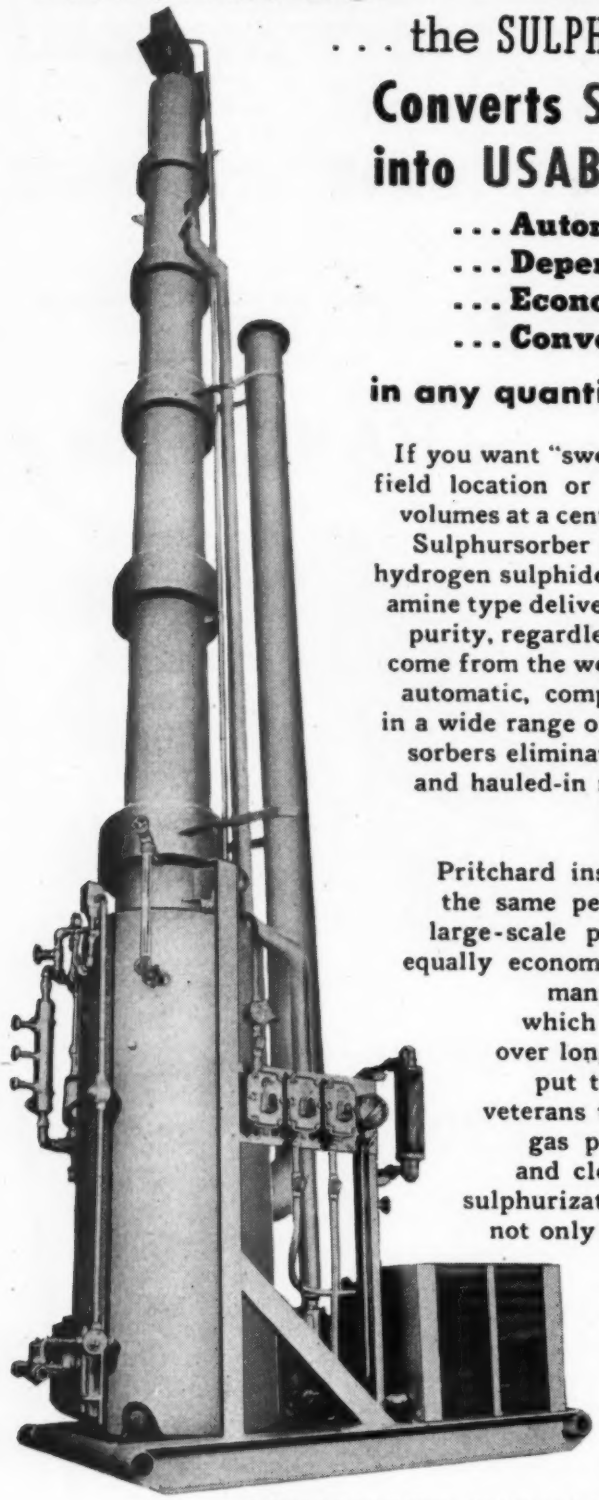

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12—Pressure Control Pilot

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Trade Literature

13—Pressure Maintenance

North Coles Levee Pressure Maintenance Project, Control of Gas Expansion, a reprint of a paper by W. J. Travers, Jr., Richfield Oil Corp. delivered at Los Angeles, April 11, 1946, meeting of API Pacific Coast Division of Production, which describes methods used by Richfield in overcoming unusual difficulties. Clark Bros. Co., Inc.

14—Centrifugal Pumps

"Pedrifugal" Pumps, Bulletin 52B6691, describes a line of pedestal type centrifugal pumps in five sizes up to 500 gpm and 100 ft. head. Includes standard dimension tables; pump, motor, and Texrope drive selection tables. Allis-Chalmers Mfg. Co.

15—Expansion Joints

Zallea Expansion Joints and Flexible Connectors, Catalog 47, includes 20 double pages of specific reference data on various expansion joints as well as instructions on the proper selection of joints for given applications. Illustrated. Zallea Brothers and Johnson.

What's New!

16—Molecular Distillation

High Vacuum Distillation, is a 16-page booklet telling the story of the molecular still, how it is used, and how to select the proper still for the job. This type of laboratory equipment may provide the only known means for distilling organic substances of molecular weight above 200, it is said. Distillation Products, Inc.

17—Hydrogenation

Hydrogenation, Bulletin 8, describes the resarch and development facilities for both high and low pressure hydrogenation, and the types of hydrogenation processes now being handled, as well as the technical service available to the industry. Hooker Electrochemical Co.

18—Stainless Steel

Allegheny Metal in the Petroleum Industry, 36-page, illustrated booklet covering specific applications, performance records, and the like of stainless steels pertaining to all phases of the oil industry. Includes information on corrosion resistance, physical properties, fabricating procedures, and forms of the metal available. Joseph T. Ryerson & Son, Inc.

19—Corrosion Control

Corrosion Resistant Materials and Equipment, Bulletin K, 16 pages of instructions for the proper selection of corrosion resistant ceramics, plastics, brick, cements, and lead in the form of tubing, coatings, linings, fittings, vessels, valves, pumps, and special shapes. U. S. Stoneware Co.

20—Water Analysis

Water Analysis, Technical and Engineering Service Bulletin No. 11; presents methods suitable for rapid work, without sacrifice in accuracy, for industrial and municipal waters, and pollution. Its 100 pages includes data on reagents, indicators, and standard solutions. Solvay Sales Corp.

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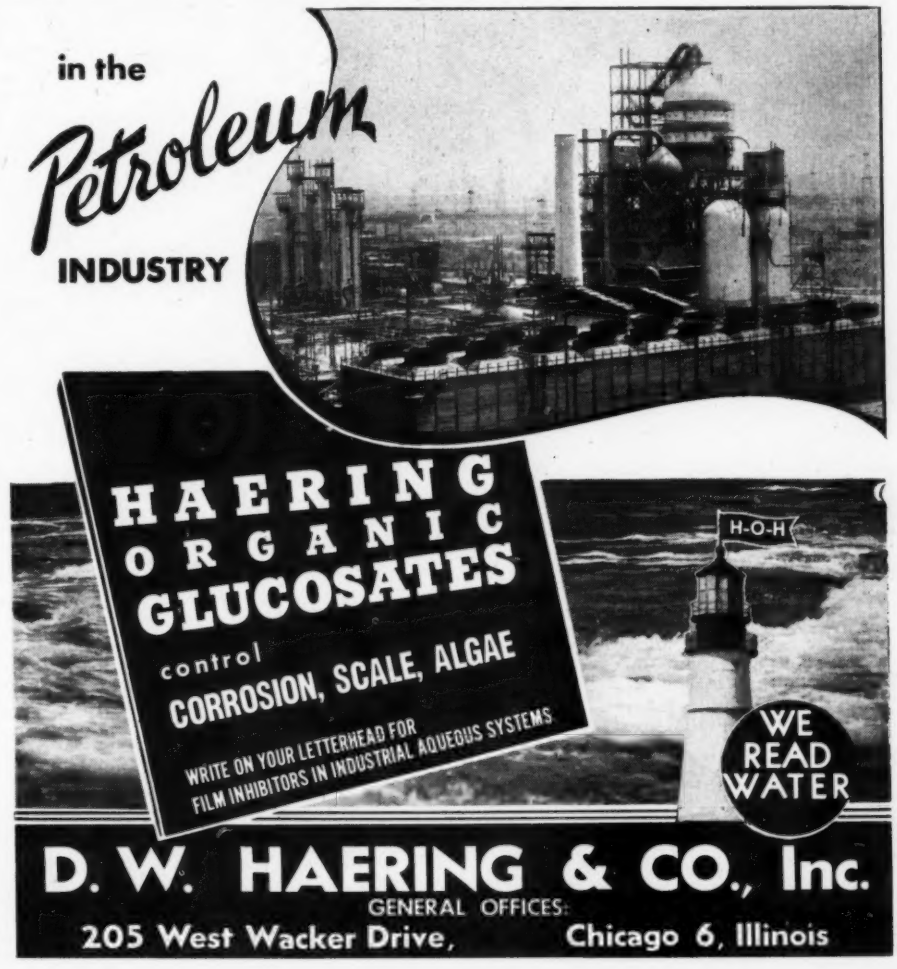

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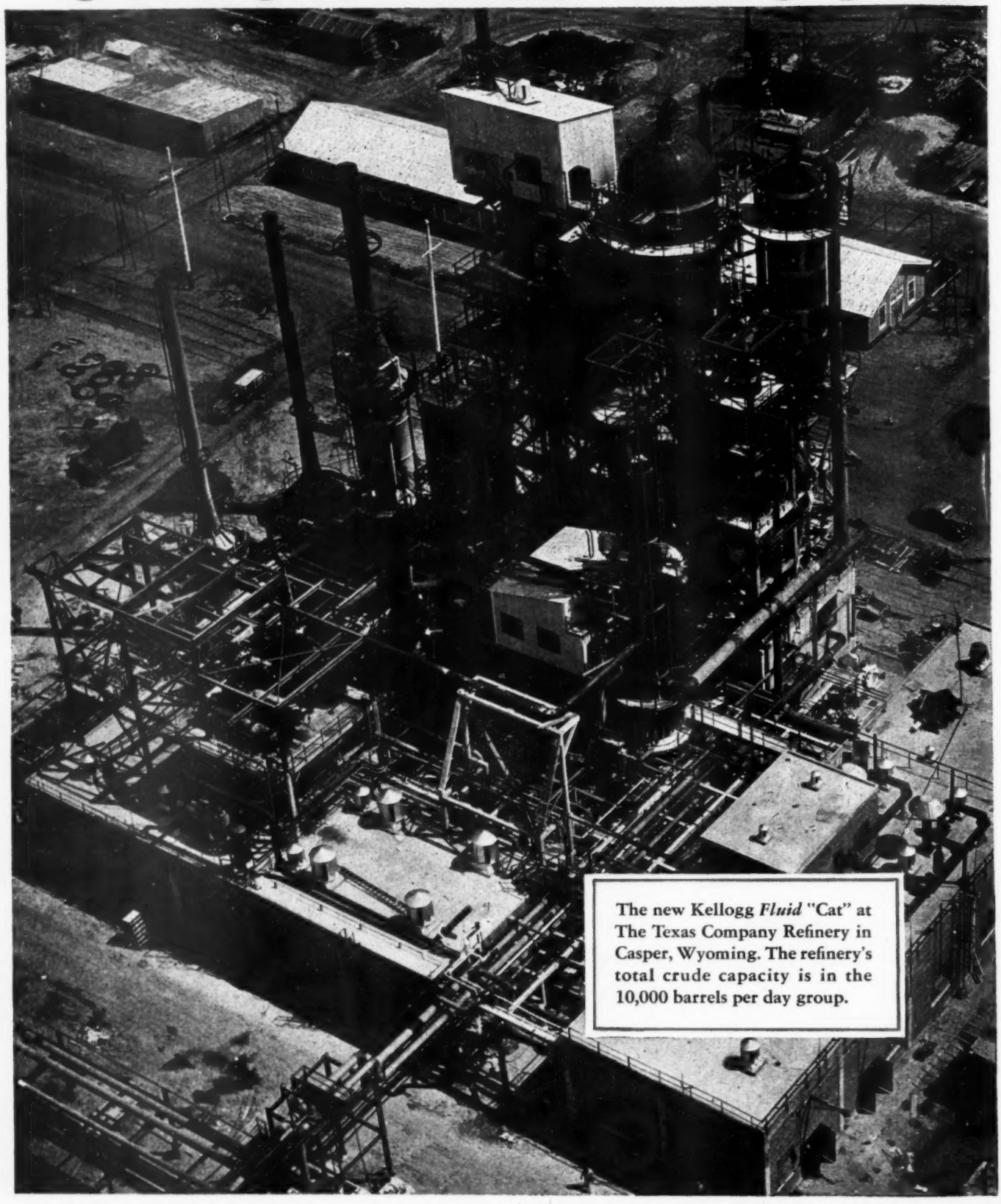

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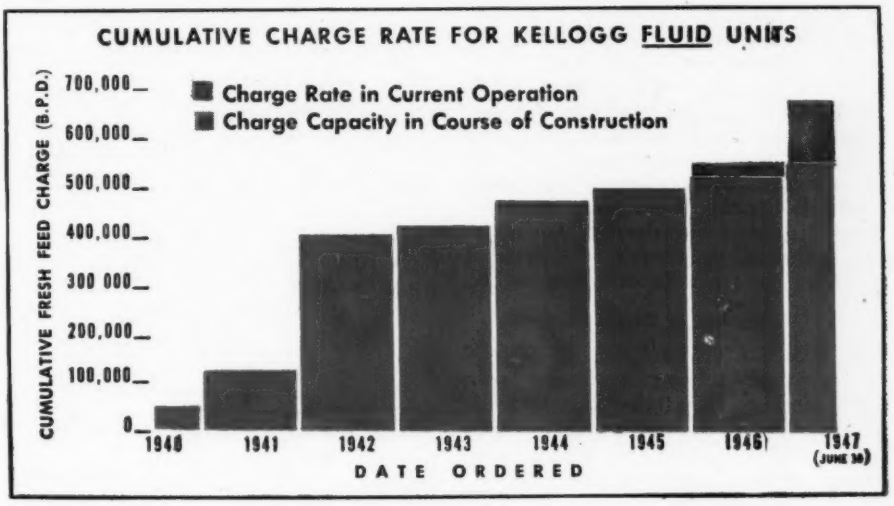

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Modifications of Oil-Water Separators To Meet Specialized Applications

By W. B. HART

In Charge of Waste Disposal, Atlantic Refining Co.

Under certain conditions in a refinery a simplified and less expensive form of the conventional oil-water separator may be used to secure satisfactory results. This month the author discusses such conditions, describes the type of equipment which may be employed, and points out the difficulties which should be guarded against.

He also reviews the important features of proper separator maintenance and operation, and then discusses the limitations of separators, including oil density, emulsions, and suspended matter.

This article is No. 19 in the series on modern methods for disposal of refinery wastes which is appearing exclusively in *PETROLEUM PROCESSING*.

THE OIL-WATER separator discussed in the preceding articles is the most modern equipment of its kind, and is applicable at any point in the drainage system where the waste is susceptible to sedimentation as a treatment procedure. The design specifically is for application at the point where the waste water is discharged to the surface waters, although in some critical locations a further final treatment may be necessary.

There may be conditions, however, under which such complete treatment is not required, or in which the waste may be especially susceptible to sedimentation. Then, obviously, a less expensive type of equipment probably will serve the purpose. Some modified forms of separators will be described rather briefly but it should be noted that the same degree of effectiveness cannot be expected from such equipment as from the complete separator described earlier.

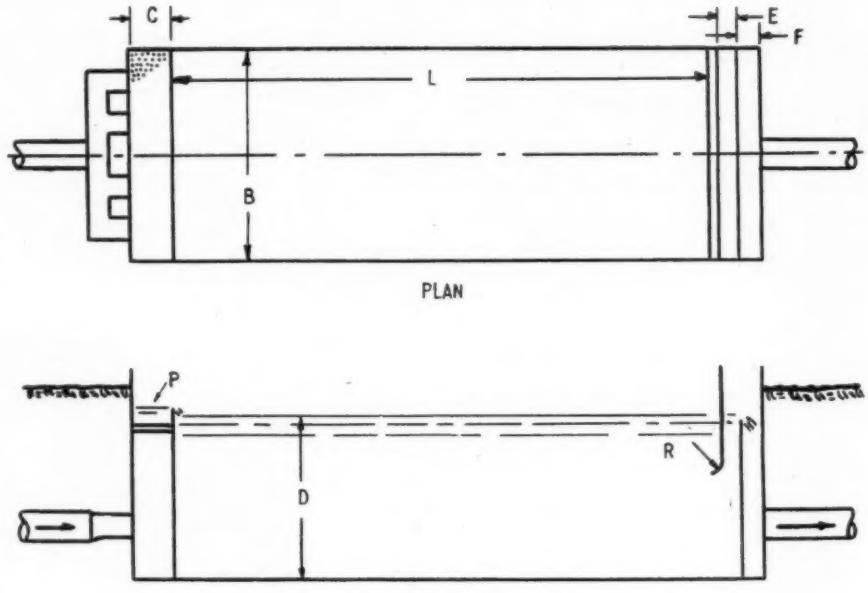
Retention of Light Oils

In a section of a refinery, or perhaps in an entire refinery producing only light products from selected intermediates, the resulting wastes may contain oil having a gravity of 40° API or higher. Such oils will rise rapidly, and usually do not emulsify readily. The operations charging or producing light oils often are rather simple, and do not employ chemical treatment to any extent. The resulting wastes usually carry little or no suspended matter. Under these conditions a rather simple type of separator will be quite effective.

It will not be necessary to describe such a separator in detail. A much better idea of its design can be had by referring to Figs. 1 and 2. It will be seen that distribution is given full attention in the design, but the film rupture chamber is eliminated. All oil is carried into the sedimentation chamber where provision is made for its collection. Separator cleaning is provided by a traveling pump and suction system. Actually, since frequent cleaning may not be required, a pump need not be kept as a part of the cleaning equipment, but can be placed as necessary.

Large separator systems, consisting of several parallel sections, may be required to meet more critical clean-up demand. Then a more careful maintenance of distribution will be helpful. To provide this condition a redistribution baffle may be employed which will divide the separator into a primary and secondary section. This arrangement is illustrated in Fig. 3. It will provide a very good separation in the absence of emulsion and any considerable amount of suspended matter.

In sections of the refinery where only finished products are stored, packaged, or moved for delivery (i. e., where there



B—Width, determined as in the complete separator.
C—This dimension same as for Film Rupture Chamber in the complete separator.
D—Depth, determined as in the complete separator.
E—Determined as in the complete separator.
F—Determined as in the complete separator.
L—140% of Primary Sedimentation Basin as calculated for the complete separator.
P—Perforated Plate, removable for cleaning.
R—Radius of Curvature, 6 in.

Fig. 1—Separator modification for light oils. Cleaning device not shown

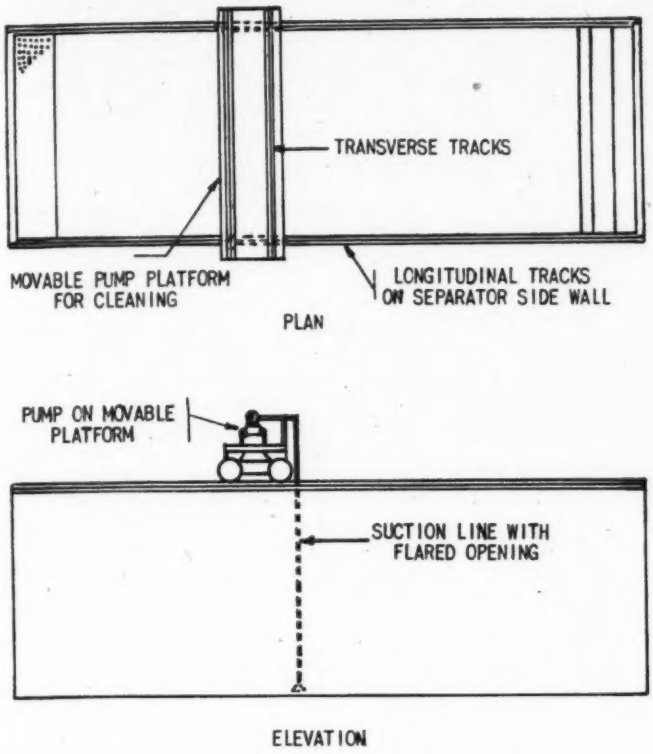
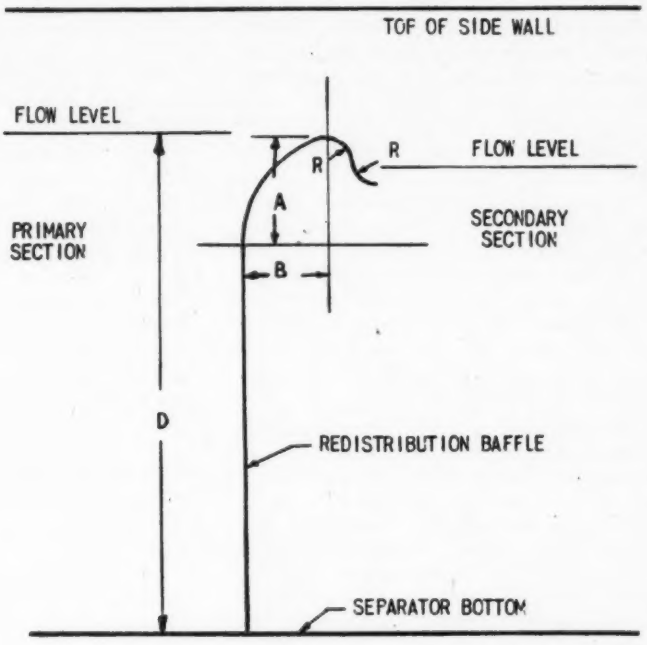


Fig. 2—Arrangement of cleaning device



R = Radius = 6 in. A = 0.125D

D = Flow Depth B = 0.8A

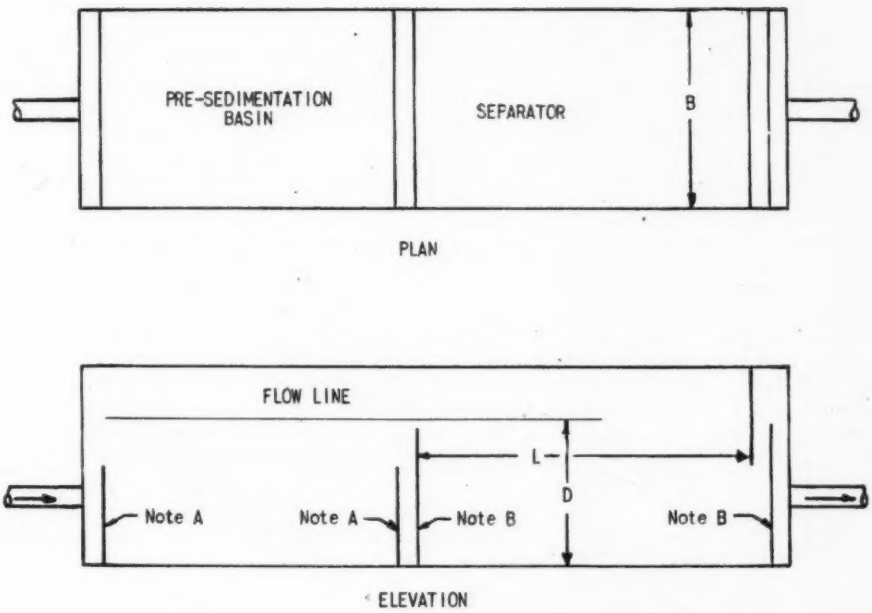
Fig. 3—Redistribution baffle

is no operation), only run-off water may require treatment. The presence of any emulsion then is very unlikely, but silt, sand, and cinders may be carried by the run-off flow. If the oil content of the waste is not too heavy, e. g., not less than the gasoline, kerosine, gas oil range, a very simple separator preceded by a plain pre-sedimentation will discharge a satisfactory effluent. The pre-sedimentation basin should be designed for ready removal of the settleable solids which will accumulate, rather than for oil separation. The latter will be a function of the separator. The basin and separator may be arranged within a single set of boundary walls, as shown in Fig. 4. When heavier oils must be retained (i. e., below 35° API at operating temperatures), a complete separator may and probably will be necessary to produce a satisfactory effluent.

When making a choice between a complete separator, such as described in the earlier articles, and some modification, such as one of those mentioned just above, greater weight in considerations should be accorded the more difficult conditions. There was hesitance about describing modifications at all, lest they be used without careful thought about what they would be required to handle.

Too often, wishful thinking, prompted by too great economy-mindedness, has resulted in the installation of a separator entirely inadequate. Then the separator is condemned, when actually the fault has been entirely with those who selected the type installed.

Complete separators have been condemned in similar manner when they have had little or no chance to function. The condemnation has come from those who either made an inadequate survey or none at all, or if they did make an adequate survey, have either ignored what it indicated, or would not take the



NOTE A—The baffles always must extend at least 1½ ft. above top of inlet sewer.

NOTE B—Height of baffle = D − 2 in.

B and D determined as for the complete separator.

L = 140% of length of a Primary Section as calculated from conditions.

Fig. 4—Simple separator with pre-sedimentation basin within the same boundary walls

trouble to study separator limitations. Then, when an unsatisfactory effluent results, the separator is blamed, rather than those who put it there. Experience has demonstrated clearly that under proper conditions separators will provide a satisfactory effluent. Their limitations will be discussed later.

There are procedures by which separator effluents may be freed of practically all oil when such a complete freedom from oil is essential to obtaining permission to discharge waste waters into surface waters. These extremely high levels of purification are not necessary in all cases as a matter of surface water protection.

Earlier in this series of articles the matter of the final destruction of hydrocarbons by bacteria was considered, as well as the various other ways in which oils are removed from water surfaces. This reference to previous articles is introduced here to emphasize the fact that surface waters can take in small quantities of oils and eliminate them. It is only when excessive rates of discharge occur that the surface waters, their uses, and the aquatic life they contain and support are harmed. The need for special treatment of a separator effluent may be regarded as resulting from failure of the separator to function completely (i. e., because of its limitations). The procedures for treatment of separator effluents will be discussed later under the topic of separator limitations.

Separator Maintenance

The mere installation of a separator does not assure satisfactory waste treatment for all time, even though there seems to be some thought that once the equipment has been constructed, and the waste introduced, it can be forgotten. It will not perform automatically. Instead, it will require proper maintenance and continual attention to its operation. The maintenance can be discussed rather quickly, so will be considered first.

Proper maintenance naturally requires that broken, worn or corroded parts be replaced promptly. This is true particularly of the distribution and outfall weirs. The knife edges of these weirs should be kept reasonably clean, and the adjustable plates replaced, or remachined, if the knife edges become notched or otherwise uneven. The weirs also must be checked frequently to assure that they are level, and adjusted as necessary.

From time to time the perforated plate which forms the bottom of the film rupture chamber should be lifted out and examined, after the Raschig rings or other packing has been removed for cleaning. The chamber packing should be cleaned rather frequently. "Rubbling" will suffice for these frequent cleanings if done carefully, so as not to break the packing. If cleaning of this nature does not give satisfactory results, and the chamber tends to "plug," there is too much suspended matter in the waste to permit the discharge of a satisfactory effluent in any event, and some other treatment procedure for removal of the excessive suspended matter should be applied prior to sedimentation.

The oil collection pipe and the flight-scraper cleaning device should be inspected with reasonable frequency to assure that they always are in condition to function properly. The pumps and lines of the bottoms removal system also should be examined. A schedule for inspection and lubrication will be very helpful for indicating when inspections should be made. A log of necessary repairs will be invaluable in pointing out failures which occur with sufficient frequency to indicate the use of different materials of construction or even, perhaps, of different design.

Operation of the Separator

Separator operation should be based upon the well defined fundamental of constant availability of design capacity. This means that the separator must be kept clean, and practically free of oil. The former, perhaps, is the more important.

The separator capacity is a function of its vertical section. Obviously, if the flow depth, which is one boundary of the section, is gradually reduced by the accumulation of settleable matter on the separator bottom, the section will be reduced in area. Then, at the same rate of waste flow, the velocity of flow will increase. Reynolds Number and turbulence will increase also, and a greater amount of oil will be carried out of the section. Bacterial action in the sludge on the bottom will cause evolution of gases. Sludge and oil-coated bubbles of gas often will rise through the waste flow to the surface. Then they break, with much whirling activity, and the oil is released as an iridescence.

The flight scraper should be operated at time intervals which will assure keeping the settleable solids on the separator bottom at a minimum quantity. At the same time it should not be operated more frequently than necessary, for it does cause some disturbance. Usually, operation once or twice each eight hour shift will be sufficient if there is care each time that the separator bottom is swept clean. The bottoms, as they are collected in the sludge sumps, should be pumped away to disposal.

There is an idea prevalent that a separator will be more effective if a layer of oil is retained on the water surface. This has no foundation in fact, nor is there any theoretical basis. It is true that when a globule of oil rises through the waste flow and contacts an oil layer, it may coalesce with the oil in the layer, thus assuring that it will stay there. But in a properly designed and operated separator it will stay there in any event. The only condition under which the layer of oil is beneficial is when all the waste passes down through a rather thick oil layer which will provide some scrubbing action.

On the other hand, large losses of oil by evaporation may be experienced when a layer of oil is permitted to remain on the water surface for any considerable time. Losses up to 30%, or even higher, may occur. As a result of the evaporation there will be created also a very serious fire hazard by the accumulation of vapors. Sometimes, in past practices, separators have been covered with slabs or other covering to minimize the fire hazard. By following such a practice, however, the conditions of a bomb are created and should the right mixture of vapors and air develop under the cover, only ignition is necessary to cause a terrific explosion. It is far better and safer not to cover the separator at all, but to keep the water surface free of oil accumulations and thereby eliminate both the fire hazard and the losses, by one simple operation.

Whenever possible, the operation of a separator should be arranged on a 24-hr. basis. There are several reasons for this. First, there are the operational requirements of the equipment itself, i.e., the continual attention already mentioned. Second, the separator is a very useful indicator of abnormal operation, serious leakages, and so forth. There is a reasonable constancy of characteristics associated with the oil collected over long periods of normal refinery operating conditions. When there is constant attention any marked change in these characteristics will be noted and can be reported to the proper personnel. Then the change can be interpreted and evaluated, and if operational abnormalities are indicated, such as excessive leakages, for example, they can be run down and corrected.

Third, a separator is not designed for great oil storage capacity. Should a serious leak occur at some point in the refinery, such as a tank bottom rupture, a large quantity of oil may come to the separator over a short interval of time. Without constant attention, which will assure that the collection facilities will go into operation promptly, the great volume of oil may overtax the retention capacity. Then the oil will escape to the surface waters and perhaps not only be lost, but also be the basis for action by pollution prevention agencies. Frequent losses of this sort well may be costly in material as well as fines or other penalties.

The necessary attention to the separators in large refineries should be given by an organization set up specifically for waste treatment and disposal activities. The head of such an organization should be responsible to management directly. In smaller plants the attention may be provided by allocation to other operating departments. This divided responsibility never is desirable, however, for it may bring about situations where the same individual who

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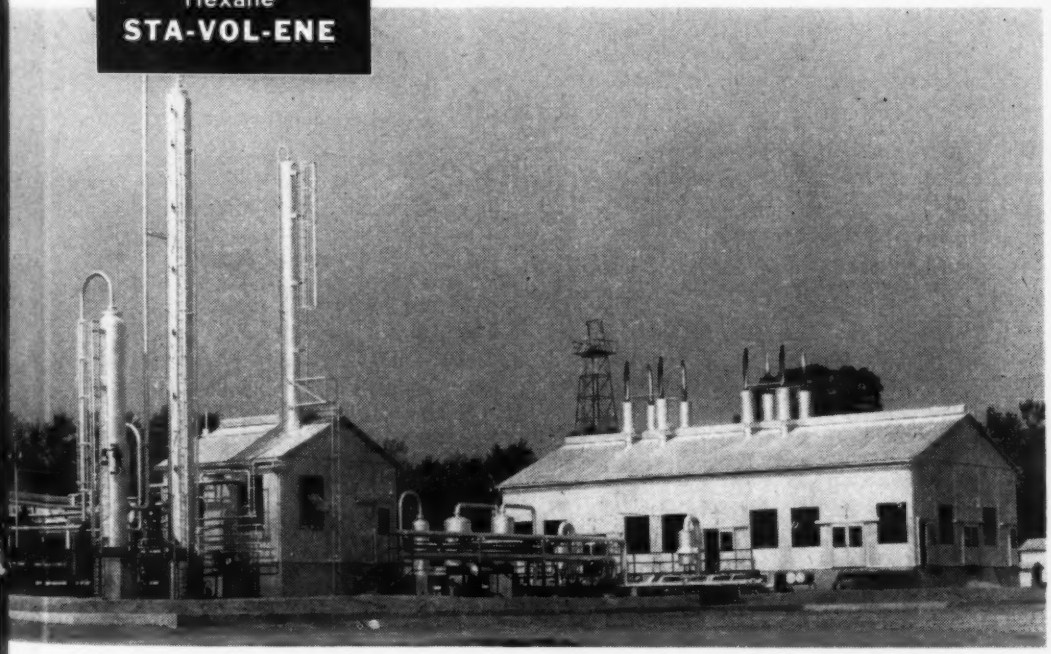

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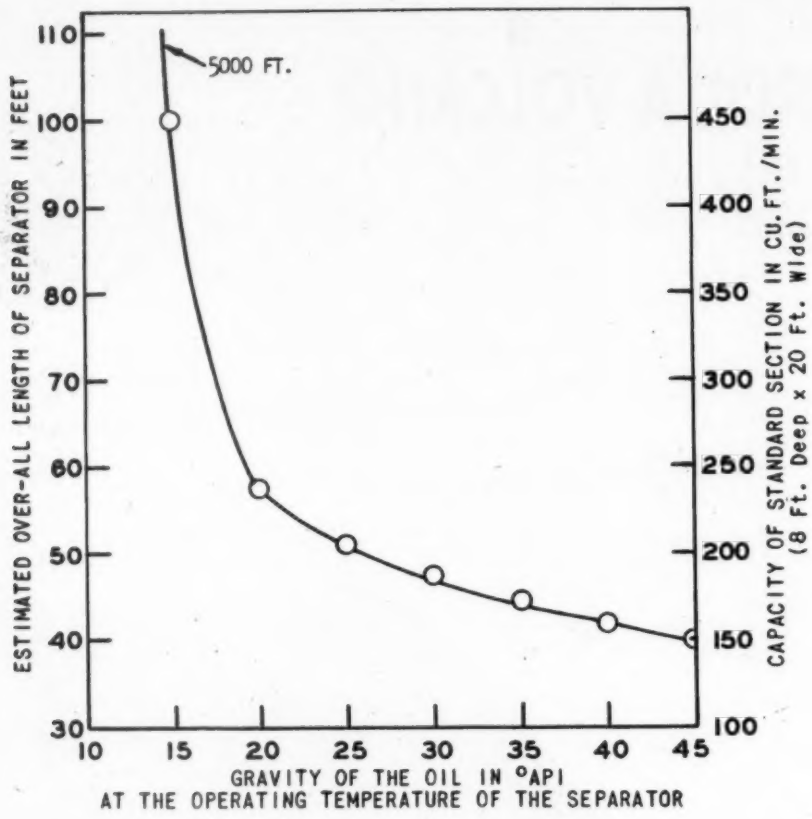

Fig. 5—Effect of oil gravity on separator length

makes the trouble also controls the correction. In such cases there always is a tendency to minimize the matter, and wrong conditions, which should be caught early and corrected, often are let go until they develop into conditions which are very serious as to both economics and public relations.

Separator Limitations

Experience has shown that all too frequently when a refinery is confronted with a waste treatment problem in which oil of any kind, or in any condition, is involved, there is the tendency toward a hasty conclusion that the installation of a separator is the right answer. This often results from an attitude unsympathetic to the proper solution of the problem, and perhaps just as often from a lack of understanding of how a separator functions, coupled with a lack of desire to learn. *No separator which operates by gravity is a panacea for all oil pollution ills.* In further support of this statement a brief review of the fundamentals of design will be helpful.

Limitation of Oil Density

Consider first the rate of rise of an oil globule as evaluated by the equation of Stokes:

$$V = [2g\,(\rho - \rho_1)r^2]/9\eta$$

In the equation there are two factors which relate to the oil. One is the gravity factor, ρ_1, and the other the globule size factor. The latter can be dismissed at once, for experience with operating separators has shown that there is little difficulty with very small globules, and that the larger ones rise with much greater velocity.

But the gravity of the oil to be separated and retained is a much more important matter. From the form of the equation it can be seen readily that since the parenthetic expression $(\rho - \rho_1)$ is in the numerator, the greater the difference between the gravity of the oil in a globule and that of the water in which the globule is suspended, the greater will be the rate of rise of the globule. Sadly, however, the converse of this also is true, and how true will be emphasized by reference to Fig. 5, in which is shown the effect of oil gravity on separator length, assuming all other items of condition to be constant. The length of separator which each gravity would require, assuming 8 ft. of flow depth, also is tabulated. Obviously, when the gravity of the oil falls to around 18° API, very serious consideration should be given other procedures for removing oil from the waste flow, for at the extreme condition, where $(\rho - \rho_1) = 0$, the oil globule simply will hang in suspension in the water, subject to the water currents, and eventually will be carried out of the separator. Other methods which can be applied under these conditions will be considered later.

Limitations by Emulsions

One of the most frequent causes for condemnation of separators as waste treatment devices is emulsion of the so-called stable type. In such emulsions the water is in the continuous and the oil in the dispersed phase. Such emulsions will mix in all proportions with water and simply color it, or give it an opalescent appearance in greater dilutions, up to the point where the oil globules are liberated and accumulate as a layer on the water surface. Emulsions of this kind are common in lubricating oil operations, in the hot-wells of vacuum condenser columns, from steam traps, light oil washing agitators, and other locations around the refinery. Their presence may not be noticed in the waste flow because other darker colorations will mask them, or free oil on the surface of the waste may conceal them. But if these interfering factors are removed by prolonged settling, the milk white, or the grayish white color, or the opalescence will appear.

Emulsions of this type carry large amounts of oil which is stabilized either electrically or by boundary chemical films. They will retain their emulsified condition for years, even though totally quiescent. A separator will have no effect upon them, for they will carry their oil content through it without change. The emulsions can be broken only by special treatments which will be discussed under the appropriate heading later.

Limitation by Suspended Matter

The successful application of separators as waste treatment units also may be limited by the presence of suspended matter in the waste flow. Indirectly this becomes a matter of lack of gravity differential and this results from the formation of aggregates in which the oil is bound.

If perfectly smooth steel balls are permitted to drop through a mechanical mixture of oil and water so that they contact oil, and then the balls are removed and washed with ether, the presence of oil will be indicated when the ether is evaporated. The oil found only could have been present as a skin-like layer on the balls when they were removed. But this layer of oil could have but little effect on the density of the steel balls, so they quickly fell to the bottom.

Assume further that fine grains of silica or other mineral substance in the form of silt were present in the waste, and that only some of the grains out of the infinitely great number present were to contact and became coated with oil. Any one, or two, or all of three effects may ensue.

1. The grains of mineral matter, being small, will have low downward velocity

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Additional physical and chemical data on this important chemical are contained in Technical Data Sheet 714, sent when requested on your letterhead. Hooker's Technical Staff is also available for consultation and help on the application of Aluminum Chloride and the other Hooker chemicals to your purposes.

SPECIFICATIONS

Hooker Aluminum Chloride, Anhydrous $AlCl_3$

Gray, crystalline solid in three sizes.

Molecular Weight 133.3

ANALYSIS

Aluminum Chloride	98.5 % min.
Iron	0.05% max.
Non-sublimables in air at 950° C.	1.5 % max.

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because of size. In such small grains the surface to volume ratio is high. Therefore, a heavy coating of oil may overcome the greater gravity of the mineral matter and the gravity of the aggregate (i. e., the grain and the oil on it) will be less than that of the surrounding water. Consequently, if the rate of rise is sufficiently great, the silt particle will be caught and retained with the oil layer on the surface of the waste flow, and will be carried off through the collector pipe. Such a result, of course, is favorable to separator effectiveness.

2. Either as a result of the thickness of the layer of oil, or as a result of the density of the oil in the layer, the excess of density of the mineral matter in the particle, above the density of the surrounding waters, just may be equalized by the deficiency of density in the oil. Then the average density of the oil and particle, i.e., the density of the aggregate, will equal the density of the surrounding water. The aggregate in this case neither will sink nor rise. Instead it will move along subject to the currents and movements of the waste flow in the separator. It will pass under or over baffles or weirs, and finally will pass out of the separator with the waste water stream and travel on to the surface water receiving the separator effluent. In the surface waters, perhaps after some short time, either agitation or bacterial action will release the oil, and oil pollution follows, for there will be untold numbers of such aggregates in the separator effluent.

3. In this case there is the reverse of No. 1, and the aggregate settles to the bottom. Then a bottom sludge heavily loaded with oil will result and must be handled carefully to avoid further pollution. A case in kind will be discussed further along in this article.

In all the types of suspended matter mentioned previously, i.e., the steel balls and the particles of silt, the surface of the particle has been rather even and smooth. The oil tends to coat them in a thin, even layer. This does not occur, however, with "floc-like" particles, which usually are irregular in shape, with variously formed indentations. The oil tends to fill these indentations, not just

A = Layer of oil on steel ball. Oil layer is exaggerated.
B = Quartz silt particle, oil coated.
C = Floc-like particle showing indentations filled with oil.

Fig. 6—Particles of suspended matter coated with oil

coat the inner surfaces, and consequently a relatively large amount of oil may be carried by such aggregates. Also, a low aggregate-water density relationship may be created, and before the aggregate can either settle or rise, perhaps due to some extent to shape irregularity, it is carried out of the separator with many others to cause oil pollution of the receiving surface waters. The ways in which oil may coat particles of suspended matter is illustrated in Fig. 6.

The matter of handling bottom settlings from separators applied where the water supply carries a heavy silt load is worthy of attention, for both economics and water pollution may be involved. A comparatively recent instance of this kind will serve well as an example, for it will point out another way in which suspended matter may limit the effectiveness of separator application.

The water supply of the plant involved carries a very heavy load of finely divided silt which, when it enters the separator, settles to the bottom. In settling, the silt has three principal effects. The silt particles which contact oil acquire a film coating and perhaps actually absorb some oil if they are porous. It is probable, however, that the particles are largely of a nature which does not permit much penetration (i.e., are like small particles of quartz and feldspar), so that the greatest number are only coated. This is the first effect.

Whatever the condition, the density of the oil and the density of the particle material merge their influence with the result that the density of the aggregate and the size of the aggregate control its action in relation to the surrounding medium. The small aggregates probably rise to the flow surface, since the effect of the oil will be dominant. But the vast majority of the particulate matter showers downward to the bottom.

The result of this condition is what might be termed a blanketing effect, and only the larger globules of oil will have the energy to penetrate it and rise to the surface. Most of the smaller globules are swept down to the bottom. This is the second of the three effects.

The third effect is that the oil so captured by the shower of aggregates or silt particles is retained in the bottom slurry and cannot escape. When such a slurry mass forms on the bottom of a container, such as a sedimentation basin, it continues to increase in particle density (i.e., number of particles per unit of volume) until it reaches a maximum which is controlled by certain natural laws. Whereas some of the oil may escape in the earlier formation of the bottom slurry, none will escape the final formation. That which does escape may be, and probably is, recaptured by the continuing shower of silt.

Summary

Thus, in summary, the effect of the silt load is to cause retardation of rise of the oil; to carry some oil through the separator on particles which neither settle nor rise; and finally to trap large quantities of oil and hold it in the bottom slurry.

It sometimes is difficult for plant personnel to understand that the slurry contains much oil, for there is a rather prevalent idea that as the silt falls through the water it is washed free of oil. This definitely is not the case, nor does it give consideration to the mass action of the silt load in the flow. The presence of the oil, and a rough idea of its quantity, can be demonstrated readily, as was done in the instance used here as an example. By placing some of the slurry in a glass beaker with about an

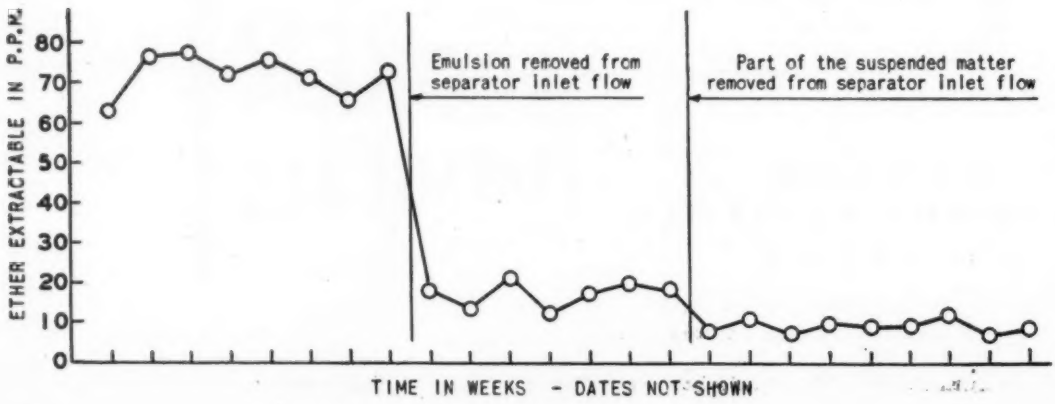

Fig. 7—Effects of emulsion and suspended matter on separator effectiveness as indicated by the ether extractable component of the effluent. The ether extractable values are weekly averages

equal quantity of clear water and gently agitating the mixture with well dispersed air under slight pressure, the oil can be separated. The agitation need be sufficient only to raise the silt up into the water so as to greatly reduce the particle density in the slurry.

It will be noticed first that a ring of oil forms around the sides of the container. This then spreads, until the whole surface of the mixture may be covered with an oil layer of considerable thickness. The oil layer then can be removed and its volume compared with the volume of slurry used as a sample. In the instance in question the amount of oil ranged from 20 to 25% of the slurry, equivalent to about one barrel of oil per cubic yard.

Obviously, then, the matter is one of importance not only from the standpoint of pollution, but also economically. Such slurry cannot be washed into some body of surface even though the silt may have come from there by way of the plant water supply. Nor can it be stored where it will be subject to weathering which will carry oil into the surface waters by flow or by seepage. The oil must be removed first, and fortunately it is economical to do so.

From design data supplied as a result of careful survey, a silt washing plant was developed. It consisted of several large, cone-bottom tanks, equipped with skimming lines, draw-off connections, charging lines, and so forth, and of particular importance, air injection lines and distributors for agitation. The compressed air, under about 20 psi pressure, is supplied by compressors which are a part of the plant. There are the necessary storage tanks and similar accessories.

The silt slurry is transferred from the separators by pumps of large capacity, and when sufficient for a charge has been accumulated in one of the cone-bottom wash tanks it is air agitated until the oil is freed and has accumulated on the surface. This requires several hours. The charge then is allowed to settle; the oil is skimmed to storage, and the silt is drained off as fill to raise the level of low ground so that the area can be used. The water added to dilute the original charge of slurry serves to flush out the wash tank and discharge lines. In the plant in question, from 60 to 100 bbls. of oil usable for charge stock is recovered daily, and ground presently of little value is being made usable for plant expansion. The economics of the procedure is beyond question. The plant has been described in some detail elsewhere (173).

It should be brought to notice here that a very small amount of oil is retained by the silt even after the washing operation. This is due to a minimum surface layer on some of the particles. Consequently, it would be questionable practice to return even the washed silt to surface waters directly. The water drainage from a fill of such silt has been demonstrated to be practically free of oil, however, and may be run off without question. The oil retained in the ground made by the silt, and it makes very good fill, soon is destroyed by the action of bacteria. It will be found good practice to fix ground thus made by encouraging the growth of vegetation and thus avoid erosion by storms and winds.

As further evidence of the effect of suspended matter and emulsions in limiting separator effectiveness, work done in another refinery may be presented. In this instance, a very well designed and constructed separator, of ample capacity, was interfered with in its functioning very seriously. The suspended matter carried by the wastes from a clay contacting plant and from other similar operations were discharged to the separator, and also the emulsion from the hot well of a barometric condenser. Such a combination of wastes always will interfere seriously with gravity type separation because the great dispersion of the oil gives greater opportunity for contact with the suspended matter.

Arrangements were worked out by which the various objectionable waste streams were treated by other methods which will be considered later. The separator effluent was carefully inspected both before and after the streams were changed, and it was found that oil in the effluent fell from the order of 60 to 70 ppm. to about 10 ppm. The emulsion was taken out first and, of course, the major part of the improvement followed. But further improvement also followed the removal of the other streams, as will be seen by reference to Fig. 7.

References

(173) Petroleum Processing, 2 (2), 102-103, Feb. 1947.

Reprints Available Soon

Reprints of the entire series of articles by W. B. Hart on waste disposal, including the final article, No. 20, to be published in September, will be made available in book form. They will be complete with all references and illustrations, as published in Petroleum Processing and its predecessor, the *NPN Technical Section*. The booklet will be 8½ x 11 in. in size, and will have a stiff cloth binding to assure durability. Copies can now be ordered at $4.00 each, postpaid, for delivery about the 15th of October. Address your request to:

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EDITORIAL COMMENTS

WIDENING HORIZONS

Court Sanctions FPC Authority To Regulate Gasoline Plants

THE Supreme Court decision in the Interstate Natural Gas Co. case upholds the Federal Power Commission in regulating sales of residue gas from a natural gasoline or cycling plant if it be "destined" to cross a state line. It also sanctions the FPC in regulating at the well-head sales, and price, of natural gas which is subject to processing operations, if the residue gas later moves in interstate commerce. Producing and gathering operations are excluded from FPC regulation, in the Natural Gas Act, only where its rules are in interference or inconsistent with the state's regulatory powers, the court held.

These considerations may greatly affect the operations of natural gasoline and cycling plants, by sustaining the principle the FPC has already put into effect in some cases. This principle is that the earnings the companies make from their gas processing operations should to a large degree be passed on to the public in the form of loyer price for residue gas. This is in direct variance with a sound conservation policy the FPC should follow by encouraging the oil and gas companies to extract liquid hydrocarbons from natural gas whenever economically practicable.

In the Interstate case the FPC had held that sale to three other gas pipelines of gas produced in Louisiana and bought or gathered by Interstate from its wells and those of others was a transaction in interstate commerce. The price the purchasers paid Interstate was too high, FPC had contended. Interstate had maintained that "gathering" was incomplete at the point of its sale and that more wells were tied into the line beyond the point in Louisiana where the gas was delivered under well pressure to the purchasers. The purchasers ran the gas through scrubbers, then compressors, before moving it with other gas across the state lines. Notwithstanding, the FPC said the gas moved in "continuous flow" from well to ultimate purchaser across the state line without interruption and "was so destined from the moment of production." These contentions of FPC weret upheld by the Court.

The same reasoning would hold the passage of gas through a natural gasoline or cycling plant to be "in continuous flow". Following the court's approval of FPC reasoning it would appear that, if the plant sells any residue gas which is ultimately transported across a state line, the transaction is in interstate commerce. Therefore, the plant operations could be held subject to the same regulations as other agencies engaged in interstate commerce.

The Supreme Court held that "unreasonable charges" exacted in a movement it has held to be interstate commerce become perpetuated in rates charged the ultimate consumer. Thus the way seems clear for the FPC to tell natural gasoline and cycling plant operators at what rates they can buy or sell gas which may later move in interstate commerce. "Contractual arrangements" which are the financial basis of plant operations would then be meaningless.

Gas purchase contracts made by natural gasoline plants usually are based on the price of natural gasoline. However, the Supreme Court's sanction seems to have been given to FPC to take into consideration the revenue derived by the plant from the sale of extracted liquid hydrocarbons in determining the price at which it may either buy gas or sell its residue gas. Eliminate the fair profit motive, as FPC apparently would do, and new natural gasoline and cycling plants will become few and far between. Practical conservation of our hydrocarbon resources would be dealt a severe blow.

Before the Supreme Court's decision, bills had been introduced in both the House and Senate to amend the Natural Gas Act to prevent such wide interpretations and administration of this law as are being made by the Federal Power Commission. The Senate Interstate and Foreign Commerce Committee failed to approve the proposed legislation, however. The misuse by FPC of its authority under the gas act may be evidenced plainly enough in the coming months that there will be even wider support from the oil and gas industries for remedial legislation in the coming session of Congress.

Fight Against Soil Corrosion Is Management's Battle Too

THE problems arising from corrosion of oil industry piping, structures and equipment are so involved in technical terms of the reactions between metals and the corrosive forces attacking them that the economic significance of what is at stake is too frequently lost sight of. This is true particularly in the case of buried structures. There the damage is out of sight and its cost, through service breakdowns, too-frequent repairs and renewals, and commodity losses, is considered necessary maintenance expense.

H. H. Anderson, vice president, Shell Pipe Line Corp., head of an inter-industry effort to lessen losses from underground corrosion, is appealing to plant operating executives for understanding and support of a program to reduce losses from this cause. "The problems of protection from soil corrosion aren't simple," he stated recently before a meeting of the National Assn. of Corrosion Engineers but addressing his remarks directly at plant managers. "Their solutions call for data, science and experience mixed with plenty of horse sense. But our corrosion engineers will work them out for us and thereby lessen industry's heavy losses from soil corrosion to the extent that WE AFFORD THEM THE OPPORTUNITY AND LEND THEM OUR SYMPATHETIC SUPPORT."

Mr. Anderson is head of an inter-industry activity which has been under way since last fall, to publicize and improve procedures arising from cathodic protection of pipe lines, communication cables, railroad signal systems and other buried metal structures. Cathodic protection is an effective retardant of soil corrosion which damages our industrial plants to the extent of at least $200,000,000 per year. To date the following 11 organizations have joined in the program.

The Assn. of American Railroads; American Gas Assn.; American Petroleum Institute; American Public Works Assn.; American Water Works Assn.; Bell System; Edison Electric Institute; International Municipal Signal Assn., Inc.; National Assn. of Corrosion Engineers; U. S. Independent Telephone Assn.; Western Union Telegraph Co. The initial objective of its Correlating Committee on Cathodic Protection is a program of education and assistance to be accomplished through issuance of general and technical bulletins.

The petroleum refiners and pipe line companies have far more at stake in this matter than most industrial concerns. For purely selfish reasons alone, their plant operating heads and executives should support this common program to apply cathodic protection more thoroughly.

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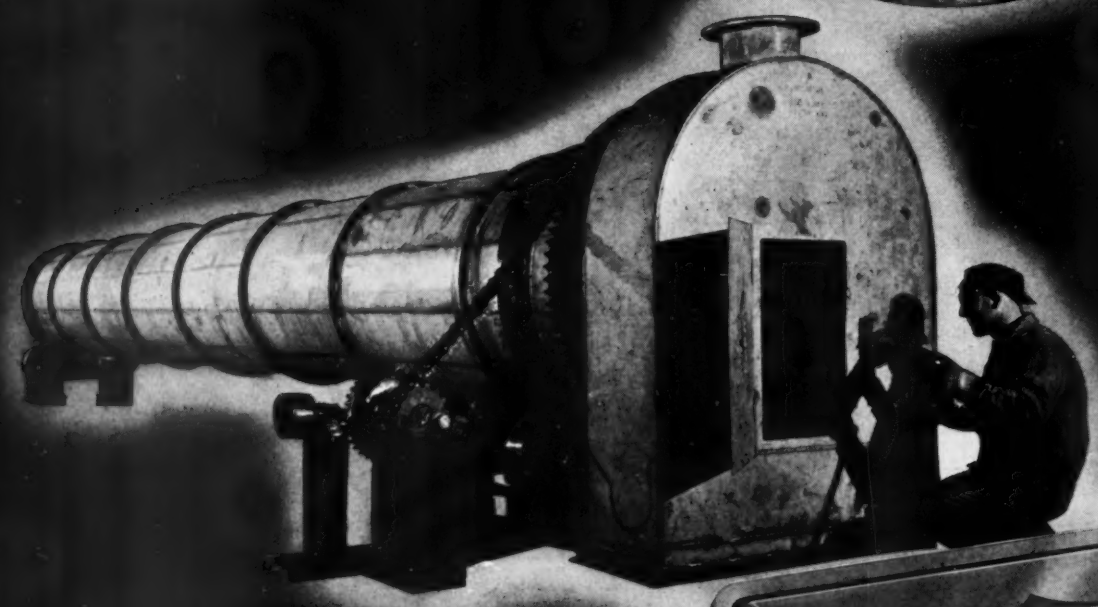

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